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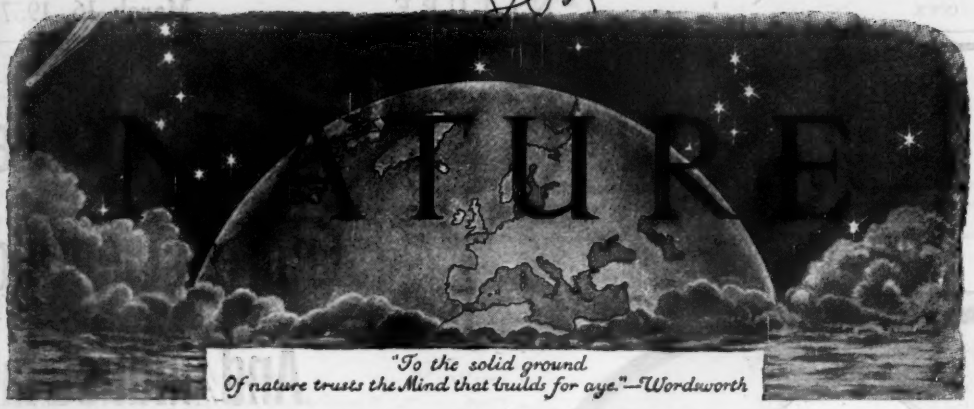

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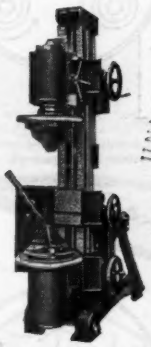

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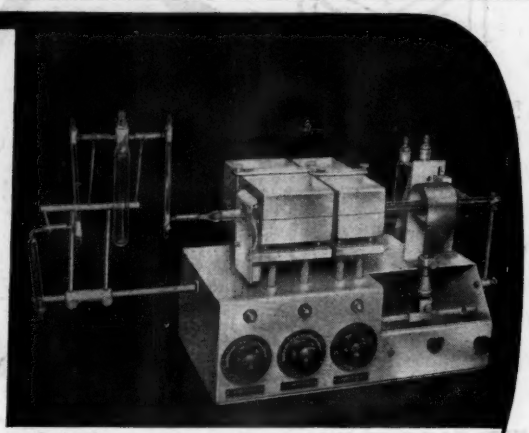

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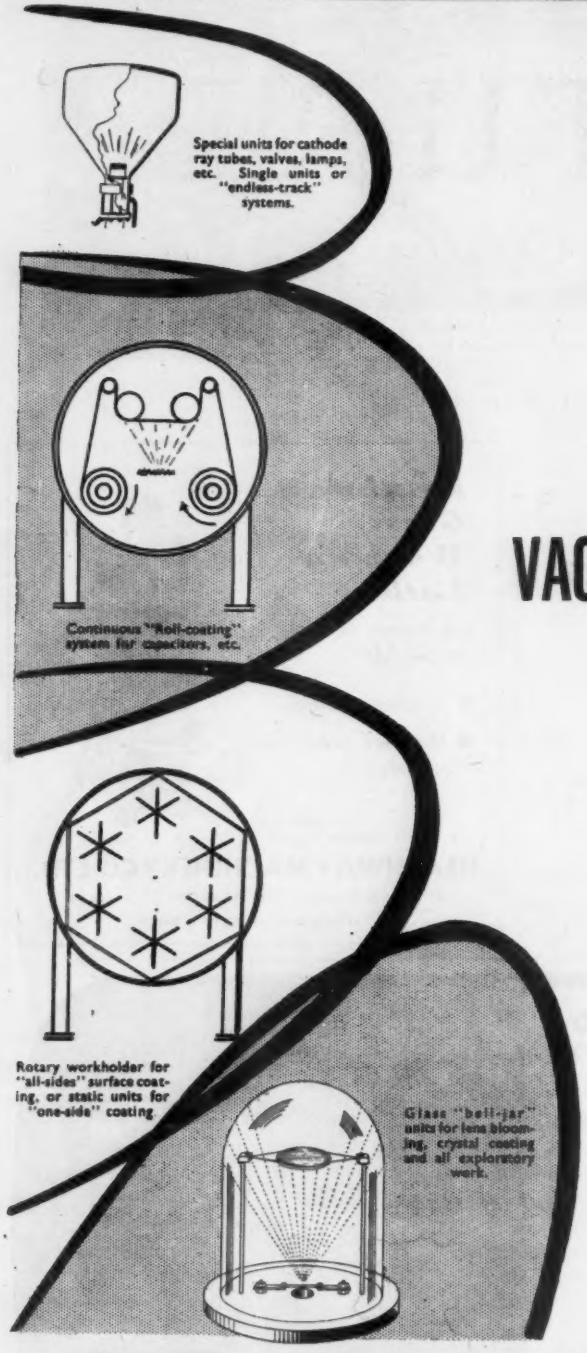
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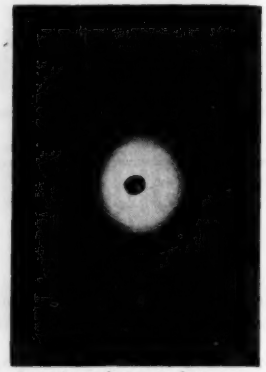

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IMPACT OF NATIONAL SERVICE ON YOUTH

THERE has recently been published, as a sequel to two earlier studies of Glasgow youths who left school in 1947 at the earliest permitted age of fourteen, a comparative inquiry* into the later history of two groups, one of 346 who have completed their National Service, and another of 222 who were rejected on medical grounds and remained in civil life. Both were members of the sample of 1,349 boys whose school lives and careers up to the beginning of 1950 were the subject of an investigation carried out by Prof. T. Ferguson and Mr. J. Cunnison, and published in "The Young Wage-Earner". A further study by Prof. T. Ferguson, "The Young Delinquent in His Social Setting", dealt with the social and environmental background of the 12·2 per cent of the boys included in the earlier and basic study, who had been convicted in the courts between their eighth and eighteenth birthdays. The same rate of delinquency was found among the 568 boys included in the present inquiry.

While this study is in succession to that made of "Disinherited Youth" by the Carnegie Trust in 1936–39 and published in 1943 and to Dr. A. E. Morgan's report "The Needs of Youth" to King George's Jubilee Trust in 1939, its prime interest is as a picture of the impact of National Service, with implications not only in the educational field but equally for the Services and for industry. Prof. Ferguson and Mr. Cunnison are cautious about generalizing from so small a sample, and they recognize that even where the influence of National Service has been unsettling, its contribution to unsatisfactory performance is surpassed by that of the bad social and environmental conditions in which many of the lads concerned were reared. The after-effects of National Service are apt, they believe, to be most severe among those of poorest background, and the dominant lesson to be drawn is that an urgent need still exists for the improvement of living conditions, and, given better conditions, the necessity of inculcating something of the art of living.

Something of this was evident in the adjournment debate on youth services in the House of Commons on January 25. In replying to this debate Sir Edward Boyle referred to the increasing percentage of those now remaining at school after fifteen. Between 1951 and 1956 this percentage has risen from 21·6 to 24·8 and the percentage of sixteen-year-olds from 9·11 to 11·8, while the numbers of those under twenty-one released by their employers for day-time study in 1955–56 was estimated at 334,000 compared with 230,000 in 1950–51. The Youth Employment Service has been established on a new footing since the War, and the inquiry now being conducted into the education of the age group from fifteen to eighteen should throw much general light on the problems involved and the best way of dealing with them. Furthermore, Sir Edward Boyle's remarks about the colleges for further education indicate some appreciation of the stress laid on them by King George's Jubilee Trust.

This bears closely on the two most disquieting features emphasized in the study by Prof. Ferguson and Mr. Cunnison. They are disturbed at the loss of potential skill between the ages of seventeen and twenty-two among both those called up for National Service and those rejected as unfit. This is not only bad for the lads concerned but also a loss that Britain can ill afford. The authors are satisfied that National Service contributes to this loss and are far less reassuring than was the working party on National Service which reported in 1955 to the Council of King George's Jubilee Trust. That report, in "Citizens of To-morrow", suggested that there is nothing fundamentally wrong with the present system and that the adjustments required are mostly within the scope of the Services themselves. The present study suggests, however, that Service authorities are not sufficiently concerned with avoiding such waste, due to their too exclusive preoccupation with Service purposes. This neglect of a precious national asset may well be aggravated if decisions on the length of National Service are dictated by political or sentimental considerations, rather than by the hard facts of national technical efficiency viewed in the context of defence requirements.

The vital importance of economy in the handling and use of man-power is also emphasized by the other tendency which disturbed the authors of this study, namely, the amount of unemployment experienced by this group in their early twenties. In a time of 'full employment' 11 per cent of them were unemployed for three months or more during the two years covered by the study. Some worked but little during the period, and less than one in four was in skilled employment at the age of twenty-two; one in three was an unskilled labourer. Prof. Ferguson and Mr. Cunnison suggest that the drift away from training is largely due to the realization by the lads that more and easier money may be made in unskilled or semi-skilled jobs, that there are plenty of such jobs available during a period of full employment and that these jobs are free from the discipline of learning or the responsibilities that often go with skill.

This situation is a by-product of the present unsatisfactory wage differentials and is a further reason for a considered attempt to deal with this difficult problem. Such an attempt is a necessary part of the effort which, the authors suggest, should be made to counteract this attitude of mind on the part of youth.

* In Their Early Twenties: a Study of Glasgow Youth. By Prof. T. Ferguson and J. Cunnison. Pp. vi+110. (London: Oxford University Press, 1956. Published for the Nuffield Foundation.) 12*s.* 6*d.* net.

They are on equally firm ground in urging that more should be done to encourage all apprentices to apply for deferment of their National Service until completion of their apprenticeships. This factual study and the restraint of its generalization put the problem of National Service into a true perspective in relation to man-power resources, and should stimulate further thought and effort to deal with the implications, both by the Services and by educational authorities and employers.

FINANCIAL RESPONSIBILITY IN BRITISH UNIVERSITIES

A TREASURY Minute*, dated January 31, 1957, appended to a Special Report from the Committee of Public Accounts for the session 1956–57, reiterates the Treasury's inability to concur in the Committee's recommendations that the Comptroller and Auditor General should be given right of access to such papers and records of the University Grants Committee as relate to non-recurrent grants. The Treasury shares the Committee's concern that the non-recurrent grants should be expended with economy and efficiency on the purposes for which they are given; but it has received explicit assurances both by the University Grants Committee and on behalf of the universities, that the obligation to observe the strictest canons of economy and of financial propriety is recognized as applying with even more than ordinary force to them, since public money is expended without being subject to the ordinary processes of financial control on behalf of the Government and Parliament.

The Treasury considers that, having regard to the special financial relation existing between the Government and the universities of Great Britain, the control exercised over the expenditure of non-recurrent grants should involve determination by the Government of the total amount of commitments in a given year, and by the University Grants Committee of the projects on which this money may be spent, and approval by the Committee of the cost of all those projects. All appropriate measures to ensure economy in expenditure will be taken by the universities themselves. Further, the Treasury will be provided with information to show that the total commitments have not exceeded the sum approved and that the accounting officer is aware of the main projects on which the University Grants Committee has decided that the money should be spent. The Treasury will then be able to review the position in good time if the pattern of expenditure in a particular year seems likely to differ widely from that envisaged by Parliament in voting the grant.

As regards the last of these four points, the Treasury has been informed on behalf of the universities that it is intended that each university and university college in Britain should formally notify its auditor of every non-recurrent grant received and the purpose for which it was made, and request its auditor to certify in general terms whether every such grant was duly applied to the purpose for which it was made.

In consultation with the University Grants Committee, the Treasury has also decided to make a number of changes, detailed in the Minute, which, it is believed, give reasonable assurance that this expenditure will be properly controlled and properly administered. Accordingly, the Treasury expresses the hope that the Committee of Public Accounts will not press its recommendation. The revised procedure will place on Treasury files quarterly statements obtained through the University Grants Committee showing the amounts paid in respect of each of the building projects detailed in the appropriate parts of the estimates. If, after the estimate for any year has been approved, the University Grants Committee wishes to alter the distribution of the non-recurrent grant by more than 10 per cent in any of the categories, it will first seek the agreement of the Treasury. The Committee will also inform the Treasury of decisions taken in respect of buildings to be started in any year and estimated to cost more than £30,000; and in recommending approval of a non-recurrent grant for a particular university, the statement forwarded to the Treasury will identify any such building project with the corresponding item in the programme already furnished. These statements will also show separately any increase in grant for such major projects already approved, distinguishing increases which are made in respect of increases in prices and wages.

Thus once again the question of the accountability of the universities of Great Britain to Parliament for some part at least of the substantial sums of public money provided for their use has been answered, and the Treasury has rightly refused to give way to the demands of the Comptroller and Auditor General. This officer is, of course, only carrying out his duty in making such recommendations, for his task is to see that monies voted by Parliament are being properly expended. Nevertheless, it has to be realized that the position of the universities is a special one, and any infringement of their autonomy, such as the suggested examination of their financial position by government officials, is an attack on the academic freedom so highly prized in the Western world. The Treasury has declared itself on the side of the universities; and it is to be hoped that the arrangements now announced will prevent the annual recurrence of this request for inspection of university accounts.

* Special Report from the Committee of Public Accounts: Treasury Minute and Abstract of Appropriation Accounts, Session 1956–57. Pp. 20. (London: H.M. Stationery Office, 1957.) 1s. net.

THE TECHNIQUE OF NATURE PHOTOGRAPHY

Zoological Photography in Practice

A Contribution to the Technique and Art of Wild Animal Portraiture. By Dr. Hugh B. Cott. (Photo Practice Series.) Pp. 370 (68 plates). (London: Fountain Press, 1956.) 52*s*. 6*d*.

IN recent years, particularly since the Second World War, students of animal behaviour, as well as ecologists and others, seem to have increasingly felt the desirability of using photographs to record their observations and to illustrate their papers. In many cases this has of necessity involved them in the problems of producing the photographs for themselves, and many have found that to produce photographs of animals, their habitats, etc., that are satisfactory from a scientific point of view is not nearly as easy as it first appears to be.

In order to produce a photograph which illustrates satisfactorily a point which he wishes to make, a worker must not only know precisely what it is that he wishes to record, but also the technique that must be employed in order to do it. Presumably most workers realize the first necessity, although this is by no means always evident in published photographs, but many, particularly in Britain, do not appear to pay much attention to the second. This may well have been due to the fact that hitherto very little worth-while information has been available in any comprehensive form on the techniques involved in the very various aspects of nature photography.

In future such an excuse for poor quality work will no longer be as acceptable, as Dr. H. B. Cott has provided just the kind of book that is wanted. Dr. Cott is, of course, exceptionally well qualified to write on this subject, as he is very experienced both as a zoologist and naturalist, and also as an artist and photographer.

The central theme of this book is zoological photography in the field, and its author's aim, which he achieves remarkably well, is to provide useful information for all who are genuinely concerned with wild-life photography.

The first six chapters are devoted to the more technical aspects of photography in the field, such as: choice of camera; selection of the most satisfactory type of sensitive material for any particular job; the right use of filters; estimation of the most satisfactory exposure to obtain a desired rendering of the tones of the subject; processing of the sensitive material both in a well-equipped dark-room and also under difficult field conditions in the tropics; and printing and lantern-slide making. This is followed by two very interesting chapters, one on the artistic approach to zoological photography, and the other, a particularly valuable one, on the scientific approach. These are followed by a couple of chapters which give an excellent introduction to the photography of animals in such diverse surroundings as equatorial forest, savannah, sea-cliff and desert.

Finally, mention must be made of the excellent drawings, tables and graphs which are used extensively to illustrate various points; of the sixty-eight art plates, some of which are very fine and all of which are reproductions of the author's own photographs; of the bibliography of nearly a hundred references; and of the comprehensive index.

Naturally, as the author himself says, this work does not cover all aspects of zoological photography; for example, there is little mention of insect or fish photography, and a section dealing with the use of the high-speed electronic flash could usefully be added in a future edition; but it will, nevertheless, be of great value both to naturalists and zoologists, and also to those whose interests are primarily photographic. This is a book which one can whole-heartedly recommend and which should certainly find a place in all biological libraries. COLIN G. BUTLER

SCIENCE IN RUSSIA

The Soviet Academy of Sciences

By Alexander Vucinich. (Hoover Institute Studies. Series E: Institutions, No. 3.) Pp. vi+157. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1956.) 16*s*. net.

THE Imperial Academy of Sciences was founded in 1725, following a decision of Peter the Great on January 29, 1724, calling for the creation of a high scientific forum to serve as a leading and unifying force for science in Russia. To-day, its successor, the Soviet Academy of Sciences, is the highest scientific body in the U.S.S.R. in all respects save the right to pass judgment on scientific validity and to explore freely the unknown and the unplanned. It deals with all branches of systematized knowledge on perhaps the largest scale in human history and receives immense financial support, and this study of the Academy by Prof. A. Vucinich should be of wide interest both to the scientist and to the technologist.

Prof. Vucinich examines in particular the organization of scientific inquiry in the Soviet Union and the social role of Soviet science and scientists. First, he summarizes the development of the Imperial Academy, which in 1917 had forty-five regular members and two hundred and twenty scientific and technical associates, until its transformation in 1929 to serve the purposes of the first Five-Year Plan of the U.S.S.R. saw the disappearance of its earlier internal organization and a vast extension of its scope, which is now governed by a statute of 1935 and various later amendments. Next, he describes the internal structure of the Academy, which is typically Soviet, in that there is a *de jure* structure conducted, at least on paper, by generally democratic processes, and a *de facto* structure tightly controlled by, and serving as an instrument of, the State. The Academy's eight departments cover physical and mathematical sciences; biological sciences; chemical sciences; geological and geographical sciences; technical sciences; history; economics, philosophy and law; and literature and language, and it is in these that research work is minutely organized and carried out. These departments are divided into well-defined research aggregates, of which the most important are the institutes; but there are also fifteen laboratories, four observatories, seven museums and five stations, supplementing the work of the institutes.

In a third chapter Prof. Vucinich reviews the contribution of the Academy to the advancement of both pure and applied science, pointing out the limitations under which the Soviet scientist works, and noting that in spite of a revived interest in theory on the part of the Academy's administrators, particularly in cosmogony and nuclear physics, advances are

likely to be strictly limited while absolute conformity to dialectic materialism and subservience to the needs of production remain. The most important function of the Academy, he considers, is to help the Government implement its various policies, but he describes at some length the relation of science to Soviet ideology and the wider orbit of the work of the Academy in training future scholars, sponsoring scientific conferences and popularizing science. In his last three chapters, Prof. Vucinich reviews briefly the place of the Academy in the Five-Year Plans, and in the social structure, and the implications of ideological purification of the supremacy of technology, and of total planning on the future development of Soviet science. Ample bibliographical references to the chapters and the appended lists of the Academy's scientific research organizations, of the academies in the Union Republics, of academicians and of periodicals of the Academy add to the value of the study as a contribution to the current debate on the implications of Soviet science and technology for Great Britain and the West in general.

R. Brightman

POOR RELATIONS

Ordinal Algebras

By Prof. Alfred Tarski. With appendices by Chen-Chung Chang and Prof. Bjarni Jónsson. (Studies in Logic and the Foundations of Mathematics.) Pp. v+133. (Amsterdam: North-Holland Publishing Company, 1956.) 27*s*.

RELATIONS have never been popular. They were utterly ignored by Aristotle and other logicians until they were introduced into logic by A. de Morgan and C. S. Pierce nearly a century ago. Mathematics uses many relations; for example, a function is a many-one relation. Apart from a few elementary definitions and easy deductions, no general theory of relations has appeared, they have never been the sole subject of a study, and there is no book about the theory of relations. Certain relations have been studied in more or less detail, such as the equality, equivalence and order relations, and in algebra and topology various morphisms. More detailed results have been obtained for well-ordering relations in the theory of ordinal numbers and semi-ordering relations in the theory of lattices. But all these form very narrow classes of relation types. The only general results consist of definitions of certain fundamental operations on relations and their most obvious consequences. For non-binary relations there is practically no literature.

Tarski has for some years been interested in the general theory of relations and this book is a beginning of a general theory of binary relations. He considers the first task is to develop the arithmetic of relation types, that is, the study of operations by means of which the isomorphism types of complicated relations can be obtained from those of simpler ones. One of the fundamental arithmetic operations on relation types is relational addition. This operation is performable on an arbitrary system of relation types which are indexed by the elements of the field of a given relation. The main purpose of this monograph is just to develop the theory of ordinal addition for arbitrary relation types.

The method adopted is to develop abstract algebraic systems formed by a set A of arbitrary elements, an operation Σ on finite or simple infinite sequences of elements of A, an operation $+$ on couples of elements of A, an operation $\breve{}$ on single elements of A, and a distinguished element 0 of A. A certain class of such algebraic systems in which the elements and the operations satisfy some simple postulates of an arithmetic character are called ordinal algebras. The first chapter deals with consequences of these postulates.

In Chapter 2 it is shown that the postulates defining an ordinal algebra are satisfied if we take A for the set of all reflexive relation types, for Σ and $+$ the known operations of ordinal addition, for $\breve{}$ the operation of conversion, and for 0 the empty relation.

There are two appendixes: the first, by Chen-Chung Chang, contains the solution of some arithmetical problems formulated in Chapter 1. The second, by Bjarni Jónsson, deals with the general operation of relational addition. It introduces the notion of a relation type which cannot be represented as a sum of relation types over a relation belonging to a set A, unless all the terms of the sum except one are equal to 0. The main result is to prove that every reflexive relation type can be uniquely represented as a sum of indecomposable types over a relation belonging to the set A, provided A satisfies certain general conditions.

Here then is a beginning of a general theory of relations; who can tell how far it will go?

S. W. P. Steen

RADIATION SHIELDING OF NUCLEAR REACTORS

Reactor Shielding Design Manual

Edited by Theodore Rockwell. Pp. xii+472. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1956.) 42*s*.

IN the past six years an extensive corpus of experimental results and methods of calculation for reactor shielding problems has been amassed in laboratories attached to the Naval Reactors Branch of the United States Atomic Energy Commission, and the existence of several shielding reactors in America has made possible a detailed study of many shield systems. This and much other work, previously unpublished or available in report form only, is summarized in this five hundred page manual.

The technique of reactor shielding falls into three parts: first, the determination of the sources of radiation in the reactor and in materials activated by its neutron flux; secondly, the choice of shield materials on the basis of their nuclear properties as attenuators; thirdly, the engineering design of the chosen materials to form a shield of least cost, weight or size. The book is arranged in the order in which it might be used in the design of a power reactor shield. After chapters on shielding theory and health physics, the shielding of core and coolant systems is treated successively. There are separate sections on shield engineering, the effect of voids, shut-down radioactivity and plant layout; experimental results and useful mathematical results are tabulated in the last two chapters, and this edition has a short index.

The merit of this manual is that it contains virtually all the available information required to

design reactor shields. Graphs, tables and nomograms are abundant and clear, and serious errors appear to be rare. However, some experimental results, particularly that on radiation through ducts, are questionable. Two main criticisms seem pertinent. The editor has stressed empirical methods of calculation at the expense of a more fundamental approach; consequently, some current theories, undeniably useful but limited in scope, may gain uncritical acceptance among newcomers to the subject. On the other hand, more experienced readers may find elementary points unnecessarily laboured; for example, four equivalent definitions of exponential decay are given where none should be needed. Secondly, the editor's choice of subject order is arbitrary; it results in certain subjects (for example, gamma-ray attenuation) being treated in as many as four different places and, as cross-referencing is inadequate, lengthy searches are required to establish some points. The text is repetitious and sometimes lacks precision, and the use of such plural forms as 'spectrums' and 'formulas' jars on British ears. However, the value of the "Reactor Shielding Design Manual" is indisputable. Revision and abridgement of the text and rearrangement of the contents would increase its usefulness considerably, and it is to be hoped that this task, together with a more critical evaluation of the experimental results and current theories, will soon be undertaken.

H. R. McK. Hyder

CELL RESEARCH

Notions de Cytologie et Histologie

Par Prof. M. Chèvremont. Pp. iv+994+10 plates. (Liège: Éditions Desoer, 1956.) n.p.

IN 1861 Brücke wrote ("Elementarorganismen", p. 386), "We must therefore ascribe to living cells, beyond the molecular structure of the organic compounds that they contain, still another structure of a different type of complication; and it is this which we call by the name of organization". Again, Hofmeister ("Die chemische Organization der Zelle", p. 20) said in 1901, "The morphologist, on the one hand, strives to elucidate the structure of protoplasm down to its finest details, the biochemist on the other, with his apparently yet still more searching methods, seeks to determine the chemical functions of the same protoplasm; broadly speaking they are only dealing with two different sides of the same thing".

Prof. M. Chèvremont's book eloquently describes and vividly illustrates the two aspects of cell research represented by these quotations. The problem of sub-microscopic organization is being investigated with extraordinary and often misguided and inaccurate enthusiasm wherever the money for an electron microscope can be cajoled out of the institutional coffers. The biochemist has been joined by the histochemist, who tries to pin-point the former's chemical substances within the cell. All this makes cytology and histology much more exciting and creates the illusion that we are rapidly approaching the stage when the cell will unfold all its secrets.

Although Prof. Chèvremont's list of contents looks scholastically formal—in its comprehensive coverage of technique, cytoplasm, nucleus, cell division, tissue, organ and so on—nevertheless, browsing through its text and admiring his electron microscope and his coloured histochemical illustrations, one cannot help capturing the scent of the intellectual excitement which lies behind these modern investigations into cytology.

The book itself is big and heavy and it has 636 illustrations, many of which are in colour. Parts of it read like a conventional text-book of histology—but interlarded with this is a wealth of new information derived from these new fields, much of which does not appear in other text-books of cytology and histology. This, in fact, is the opening of a new era in this sort of publication. Text-books of histology in ten years time will not be recognized by the Sharpey-Schafers of yesterday.

One feature of this volume to be highly recommended is the inclusion at the end of each section of a series of general references which enable the reader to search further in a subject which catches his interest. There is also a valuable subject-index. It should be mentioned that the text is in French, but perhaps it is permissible to refer to the fact that the Pitman Medical Publishing Company is engaged in the production of a translation of this work.

G. H. Bourne

CONTINENTAL ECOLOGY

Synökologie der Landtiere

Von Dr. Wolfgang Tischler. Pp. xvi+414. (Stuttgart: Gustav Fischer Verlag, 1955.) 36 D.M.

TISCHLER'S book is outstanding in that it goes a long way towards bridging the gap between the Anglo-American and the Continental approaches to ecology. By restricting the field to terrestrial animals and habitats for his examples and for consideration in the 'special part', Tischler has been able in four hundred pages to cover an impressive amount of ground. Throughout the first half of the book the accent is on synecological work, one of the precepts enunciated at the beginning and strictly adhered to being that it is not enough to study the single species and its immediate environment if its ecology is to be understood. This part of the book is concerned with principles, and successfully welds together subjects such as population fluctuations and succession on one hand, and biocenotic classifications, life forms and the ecology of man-made habitats on the other.

The second half of the book treats each of eight main climatically determined vegetation types in turn: shore, rain forest, deciduous forest, tundra, conifer forest, desert, steppe and bush and their variants. The discussion follows a uniform but not rigid plan under such headings as "Living Conditions", "Structure", "Food", "Biotic Relationships" and "Over-Wintering". These chapters are followed by a section on land types which result from human activity ("Buildings", "Gardens", "Ruins", "Arable and Pasture Fields" and "Hedges") which is the special interest of the Kiel ecologists. A final chapter is an appeal for an enlightened land management and nature conservation.

This is frankly a text-book and source of information. For this reason, perhaps, the treatment is mainly terse and impersonal. More controversial topics are either avoided or briefly mentioned by quoting references on both sides. Two features stand

out as being particularly useful for the student. First, there is a quite exceptional lack of jargon, and secondly, there are a large number of text figures drawn by Tischler in order to summarize the data of other authors' papers; these are mostly clear and easily understood.

To readers in Great Britain, Tischler's book should be of immense value as an introduction to Continental work on animal ecology, especially as practised by the German-speaking countries. It is also of great interest as a balanced appraisal of British and American work and the way it fits into a broader background as seen by one who is particularly concerned with the practical approach prevalent in present-day Germany. AMYAN MACFADYEN

A MYSTIC FROM FRANCE

The Notebooks of Simone Weil

By Simone Weil. (Translated from the French by Arthur Wills.) Vol. 1: Pp. iv+332. Vol. 2: Pp. iv+333–648. (London: Routledge and Kegan Paul, Ltd., 1956.) 56s. net the set.

CONFRONTED by a couple of well-produced volumes containing the disjointed thoughts of an obviously first-class brain, a reader might well expect some editorial comment, or at least some kind of introductory note. But there is nothing of the sort. Without a word of preparation, the text opens, the author beginning with a few lines of intense concern for human suffering, followed by a reference to the eternal problem of values, the nature of beauty and of art; and so on over almost the whole domain of knowledge. It may perhaps be said that this method of presentation has the advantage that no outside hand has been at work to deflect the gifted writer's aim, but one may not unfairly ask what her aim is.

In the usual sense of the word, there is probably no such thing for Simone Weil. Having already written several books (notably "The Need for Roots" and "Gravity and Grace"), these note-books were intended to form, so to speak, the water at the bottom of a deep well from which could be hauled up the (fluid) material for any number of future speculative ventures, including maybe a volume on folk-lore which might have emerged as something not ashamed to take its place within sight of "The Golden Bough". The relentless search for absolute truth is reminiscent of Pascal and of Husserl: both these savants, however, had a plan, even in their fragments, but here there is no plan. Yet again, one is reminded of Edith Stein, a pupil of Husserl's. Another glance at Simone Weil's outlook and the likeness vanishes, except for their common courage and self-abnegation. It is the difference between repose and rebellion, between peace and the sword.

Judged by her writings, it seems that Simone Weil was constitutionally incapable of coming to terms with any agency upon this earth, civil or ecclesiastical; and by these exacting standards, her meditations must be assessed. Even when considering the teaching of the Spanish Mystics (a fairly close parallel with Edith Stein's "Kreuzwissenschaft"), she adopts a fundamentally reactionary attitude, at once serious and defiant.

Metaphysical as much of all this may be, there are some surprisingly down-to-earth entries, reinforced by flashes of French logic. Thus, time and again we find the theme of physical work—in the sense used in thermodynamics—coming to the fore, coupled rather naïvely to the urge towards manual labour on one hand and (more carefully) to such concepts as order–disorder and entropy on the other. It can scarcely be an accident that these almost axiomatic elements in the theory of heat are found more frequently than others in the writings of the philosophers. Simone Weil wanted to collect all the experimental data extant about work and heat, but like the Greeks of old, she always fell back upon the majesty of abstract science.

In fact, in her own semi-mystical way, she puts a fine point upon the age-long argument concerning the contrast between the complete detachment of Hellas (and perhaps of almost every true philhellene) and the Renaissance, with its discovery that not only does man want to 'master' Nature, but that he can indeed do so, to a very large extent indeed. With this will to conquer came, it seems, the separation between science and art. The insatiable curiosity of the Greeks, and the materialism of the Romans, are noted as but mere examples in the unfolding of history. Between pure and applied science there is indeed a great gulf fixed.

Typical of this outlook is a note on p. 157. "Find somebody who can tell me whether the second principle of thermodynamics is regarded as valid in biology?" Conceivably, if Simone Weil's voracious appetite for reading had included Prof. Bertalanffy's "System Theory", she might have found the answer. This ingenious calculus provides, as is commonly known, for 'open' systems; whether it will stand the test of time remains to be seen. It depends upon a degree of balance unlikely to be attained in many categories of mechanical assemblages. But the point is significant; she recoils from the idea of total degradation of energy. Within limits, she may be right, and there the quantum theory supports her.

Psychologically, it would be an almost impossible task to place Simone Weil. In broad outline, she must have been a strong introvert. Her passion for serving others, however (for example, her work for the resistance movement of her native land), designates her an extrovert indeed. But the link which united the two, in unstable equilibrium, was a kind of Aristotelian potency, straining at the leash to pass into entelechy at the slightest provocation. Her whole life appears as a sublime human example of the physicist's critical state; the phenomenon of flickering striæ associated with a condition in which pressure and volume are increasing simultaneously.

It will be noticed that this review refers to the composer of these note-books in the past tense. All too little known, and still less revered in her lifetime, Simone Weil was born in 1909. At one time she taught in a French secondary school, and at another period voluntarily engaged in strenuous manual labour. She was in England during the Second World War, died at Ashford (Kent) in August 1943, and was buried in a common grave, No. 4779. Quite recently, a movement has been set on foot to erect some simple memorial of her.

These nascent jottings give the impression of an intense striving for intellectual and spiritual perfection on the way to further creative effort. But they represent all too clearly what in the event proved to be the last will and testament of a tortured mind. F. I. G. RAWLINS

The Chemistry of Living Cells

By Prof. Helen R. Downes. Pp. x+549. (London: Longmans, Green and Co., Ltd., 1955.) 45*s*. net.

THE book is a very useful introduction to biochemistry for biologists. It is well written and thoroughly up to date in the topics which it treats. The historical introduction is useful and well balanced. The introduction is followed by two chapters dealing with some selected properties of aqueous solutions and the structure of living cells. The further subdivisions of the book deal, on one hand, with organic constituents of cells and, on the other, with intermediary metabolism.

However, there are a certain number of rather serious deficiencies. The physico-chemical side of biochemistry is very inadequately treated and in particular there is no account whatever of rate processes. Thermodynamic considerations are scarcely mentioned; and what is surprising, considering how very up to date this book is in other respects, is the lack of incorporation of the very large amount of information which has been derived in recent years from cytochemical studies. Neither the information which has been obtained by the study of tissue sections by cytochemical methods, nor the information which has been obtained by the fractionation of cells into constituents such as nuclei and mitochondria, is in the least adequately presented. This lack is a grave disadvantage from the point of view of the average biologist. It is also unfortunate that that there is no discussion of macro-molecular specificity and interactions such as are involved in the formation of antibodies and their interaction with antigens.

Nevertheless, these rather striking disadvantages are often characteristic of the teaching of biochemistry, and can scarcely be considered an individual failing. As books go which treat of the chemistry of living cells, this is to be highly recommended.

J. F. DANIELLI

Information Theory

Papers read at a Symposium on "Information Theory" held at the Royal Institution, London, on September 12th to 16th, 1955. Edited by Colin Cherry. Pp. xii+401. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1956.) 70*s*.

LONDON Symposia on Information Theory have become something of an international institution, and readers of *Nature* may remember Dr. E. C. Cherry's account of the third, held in September 1955, at which scientists from many disciplines and from many countries exchanged ideas and problems in this borderline territory. The published Proceedings, which make a volume of more than four hundred pages, have had to be somewhat condensed, but only a few papers, which were submitted but not read, are printed in abstract. The papers presented cover semantic aspects of the subject in addition to the Wiener–Shannon statistical calculus, and include several on biological and other topics which belong to information system theory if not to information theory itself. The whole affords a remarkable indication of the scope and usefulness of the new methods of approach which information theory makes possible.

This is not to say that all current applications of the theory are of equal value or of equal promise. At this exploratory stage it was intended that these symposia should offer scope for tentative essays designed to stimulate discussion as well as for more solid elaborations of established technique. But the net effect is to make this a much more stimulating volume than if it were less controversial, and the new reader has the more incentive to develop his own judgment in a field where judgment is needed.

Defects and Failures of Metals

Their Origin and Elimination. By Prof. E. P. Polushkin. Pp. xvi+400. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1956.) 72*s*.

ONE of the more chastening tasks of the metallurgist is to examine the failures of metals during manufacture or service, and to ascertain its causes. This diagnostic work requires a sharp eye, good memory, and long experience. Over the years a vast number of threads have been established, from practical experience, connecting the visible defects of metals with all the irregularities of composition, fabrication, and heat treatment, inherited from manufacture, and with the various severities of stress, heat, and environment, encountered during service. The value of Prof. Polushkin's book is that it lays out these threads in large numbers, plainly and simply, extracted partly from his own experience, partly from a vast bibliography, and that it emphasizes particular peculiarities rather than broad consistency of behaviour. The subjects treated include segregation, porosity, piping, impurities, decarburization, scaling, residual stresses, fatigue, flakes, overheating, burning, embrittlement, cracks, distortion, wear and corrosion. The book is essentially a collection of notes, a guide to the literature, and as such it will prove a useful work of reference for the specialist in metallurgical autopsies. But it is a decidedly unsuitable companion for a long aeroplane flight.

A. H. COTTRELL

Adventure of the Sea

By James Fisher. Pp. 70. (London: Rathbone Books, 1956.) 15*s*. net.

A BEST-SELLING novel, a number of dangerous voyages by rafts and small boats, submarine exploration with artificial lungs, and the discovery of remarkable relics like *Latimeria* and *Trigonia* have led to contemporary interest in the sea on a scale unsurpassed since the rise of rapid communications. Because of this interest, Mr. James Fisher and his publishers have shown admirable discernment in producing this book, which should find a ready audience. The title is somewhat misleading as the contents include not only accounts of the way in which the sea has been fought and overcome by man but also of the animals which live in, above and near the sea as well as the use made of the sea and its products by man. This, however, is but a small blemish in an excellent book which, besides clearly written text which combines science, technology and history to make a smooth-running narrative, contains a remarkable collection of more than two hundred paintings, maps and diagrams in a profuse range of colours. However much the purists may object to some of these, the reader for whom the book is intended will be caught and captivated. It is most unfortunate that the binding will need immediate reinforcement from those who wish to keep the book in one part.

T. H. HAWKINS

ORIGIN OF TEKTITES

By Prof. HAROLD C. UREY, For.Mem.R.S.
University of Chicago*

THE origin of tektites has been discussed for many years, and no satisfactory solution to the problem has been proposed. They definitely show flow patterns indicating travel at high velocity through gas such as the Earth's atmosphere. Their chemical composition shows that they are not obsidian and, in fact, they are similar in composition to sedimentary rocks without their water content. In particular, they contain several per cent of potassium oxide (K_2O), 1·5 p.p.m. of uranium and have very high silica and alumina contents. Spencer[1] and Barnes[2] list many analyses of these objects. Their chemical composition is produced on Earth by most complicated processes, including the weathering of granite and basalt and the removal of the alkaline earths and iron by the action of water. If they are extra-terrestrial in origin, then the question arises as to how their composition was produced elsewhere. Volcanic sources of heat are not sufficient to have melted them, and yet their arrival from space with the distribution found on Earth is not possible either, as I have pointed out[3].

Briefly, the argument is as follows: (1) If a large mass of glassy material arrived and broke up in the atmosphere, the parts should have distributed themselves over an area some tens of kilometres in dimension, as is observed for certain meteorite showers. The distribution over all southern Australia, for example, would be impossible. Hence, the compact-mass arrival is excluded. (2) If the tektites arrived as a swarm, its mean density must have been greater than 10^{-6} gm. cm.$^{-3}$, for otherwise solar gravitational forces at the Earth's distance from the Sun would break up the swarm and tektites would become distributed over the entire Earth. Yet a swarm of this density some 10^8 cm. in diameter would pile up tektites to a depth of 100 gm. cm.$^{-2}$ over southern Australia, and this is not the case. Arrival from the Moon raises similar objections. I know of no answer to these arguments.

Spencer[1] many years ago suggested that meteoritic falls may have been the source of melting of terrestrial materials; but no evidence for meteorite craters could be found in the neighbourhood of the various tektite areas. I suggested that a minor planet may have collided with the Earth and the enormous crater may have initiated some major plutonic effect which covered the crater. This was always regarded as a last resort type of suggestion.

The approach of the comet Arend-Roland stimulated a little further thought on this problem. What would happen if a comet collided with the Earth? A comet head consists of a very loose aggregate of small particles, and recently it has become evident that these particles consist of, or are mixed with, chemical compounds having large amounts of energy. In fact, the material is a high explosive which 'burns' quietly under excitation by high-speed particles from the Sun only because of its very loose structure and low density (see Donn and Urey[4] and references there given). Since comets move on nearly parabolic orbits, their velocity at the Earth's distance from the Sun is 42 km. sec.$^{-1}$. The heads are estimated to be 10–70 km. in diameter and their density may be 0·01 gm. cm.$^{-3}$. The kinetic energy of a spherical object 10 km. in diameter of this density and velocity would be 5×10^{23} ergs, which is equivalent to 5×10^7 atomic bombs of the old-fashioned fission type, or a half-million hydrogen bombs. The chemical energy would only be a fraction of this, perhaps 10^{27} ergs, or even somewhat more.

If an object of this kind entered the atmosphere at this high velocity, compression and heating of the material would occur. It would explode in a chemical sense, and most of its mass would be converted to gases at high temperature. The amounts of silicates expected to be present would be volatilized or scattered as fine dust. Such compaction would be effective at 60–100 km. above the Earth's surface and the explosive reaction should begin at this altitude. The high-temperature mass would continue to move towards the Earth, heat its surface quite easily to the melting point, produce a very compressed region of gas, and this would propel terrestrial material in all directions at high velocity. It is difficult to predict the type of crater to be expected. However, the explosion would resemble the high air burst of an atomic or hydrogen bomb; but the effects would be very much greater and somewhat different because of the great mass of gas both from the detonation of the comet head and from the compressed and heated air, and the much lower temperatures distributed throughout the mass. One would expect the general effect to be more that of a propellant than a detonating type of explosion. The mass would be stopped within one second and the maximum pressure would be about 40,000 atmospheres. Probably a very broad area would be involved and no deep penetration in a limited area would result.

If they are a by-product of a cometary collision, several puzzling features of tektites are explained. (1) Their material substance comes from the surface of the Earth, and hence varying compositions are to be expected; even the nearly pure silica of Libyan glass, and in fact the americanites, which are not usually included as respectable tektites because of their obsidian-like composition, could also owe their existence to this process acting upon granitic rock. (2) The high temperature required for melting is provided. (3) They were melted quickly and briefly and hence did not lose their alkalis, which are known to be very easily volatilized from melts. Also the presence of melted quartz particles, that is, lechatelierite, is understandable. (4) A mechanism for scattering over wide areas is available. (5) The flow marks could have been produced by the blast of hot gases over more slowly moving objects. (It has always appeared surprising to me that a small glass object, 1–2 cm. in diameter, would travel at high velocity through the atmosphere, keeping one orientation as is necessary in the case of the more 'button-shaped' tektites. A blast of high-temperature gas could

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produce this effect very quickly, and seems a more probable mechanism.) (6) Since more basic materials will crystallize rapidly even during cooling, it can be expected that only very acidic tektites will remain glassy and thus be observed. (7) The residual crater may be very difficult to identify; but it might well be looked for while keeping some flexible ideas as to what its properties may be.

The number of comets observed to arrive near the Sun is about 10 per year and the true number may be larger. Assuming completely random orbits, the chance of one hitting the Earth is $\frac{\pi a^2}{4\pi R^2} \times 2$, where a is the Earth's radius and R the distance of the Earth from the Sun. The factor 2 takes account of the chance of collision while the comet approaches the Sun and when it leaves again. There is a small increase in cross-section of the Earth because of its field. Approximately the factor is $\frac{a^2}{R^2}$ and this equals $1{\cdot}8 \times 10^{-9}$. With ten comets arriving per year, only one collision in 50 million years could be expected, and this is far too small to account for the many groups of tektites observed. Father P. J. Treanor has directed my attention to the strong probability that heads of comets may be loose aggregates that may break up during an approach to the Earth and separate masses may fall nearly simultaneously at widely separated points. In this case only one collision is required. It is interesting to note that many of the various kinds of tektites are Pleistocene in age and may be contemporaneous in origin. Only the Texas tektites appear to be of Eocene age and are thus about 50 million years old, and this is just the mean time between collisions calculated above.

The suggestion advanced in this article may appear to many as too hypothetical to deserve the light of day. However, the tektite problem has been, and is, one of the major puzzles to men "who pick up rocks and stop to think" even before the classical paper of Suess of 1900 [5] appeared, and conservative proposals have been found to be inadequate. It is often remarked that no tektite had even been observed to fall. If the present suggestion gives the true origin, all will agree that any demonstration of the process would cost far more than the scientific knowledge gained would justify. Yet such catastrophic events, some large and some small, should occur about once in 50 million years.

[1] Spencer, L. J., *Min. Mag.*, **25**, 425 (1939).
[2] Barnes, V. E., Univ. of Texas Publ. No. 3945, pp. 477–656 (1950).
[3] Urey, H. C., *Proc. U.S. Nat. Acad. Sci.*, **41**, 27 (1955).
[4] Donn, B., and Urey, H. C., *Astrophys. J.*, **123**, 339 (1956); also Seventh Liège Astrophysics Symposium on Molecules in Astronomical Objects (July 1956).
[5] Suess, F. E., *Jahr. Geol. Reichsanst. Urien.*, **50**, 193 (1900).

ORIGIN AND MODE OF FORMATION OF CERTAIN LOCAL STAINS ON SILVER TABLEWARE

By D. BIRTLES, E. JACKSON and M. THOMSON
Sheffield Smelting Co., Ltd., Sheffield 4

THE loss in brilliance of silverware is generally caused by the formation of a silver sulphide layer, which is easily removed by normal cleaning methods. In recent years, however, a different type of stain has appeared, usually taking the form of small local and often circular dark spots, which are most difficult to remove, the proprietary dip cleaners and the aluminium–soda process both being apparently ineffective. This modern malady of the silver-plating world has been frequently attributed to faulty electroplating, and many complaints have been received by manufacturers. It is the purpose of this article to show how such stains may be formed on any silver surface and why the phenomenon is more prevalent nowadays than it was in previous times.

Origin of Stains

Observation of many stains showed that they varied in colour from almost black to a pale straw, with some intermediate ones exhibiting colours due to interference. For some time there has been a general feeling in the plating trade that these stains were somehow connected with the use of detergents for washing up. A report published by the Master Silversmiths' Association confirmed this, stating that "stains are formed very rapidly when solid common salt is dropped on to the surface of the article when it is immersed in moderately hot water containing certain synthetic detergents. It appears that only detergents containing oxygenated compounds such as percarbonate, perborate and persilicate induce the salt to act on the silver in this way and the action does not occur when the salt is completely dissolved in the liquid".

Experiments were performed to confirm these statements, and it was found that stains could be produced by common salt particles when the silver was immersed in a dilute acid or alkaline solution or merely in water. This indicated that the oxygenated compounds and the detergents themselves were not necessary to produce the stains; but it was confirmed that a homogeneous salt solution would not cause staining. Reagents other than common salt were tested for staining properties. It was found that potassium chloride, ammonium chloride, potassium bromide and sodium iodide all produced stains under similar conditions, that is, on being dropped through water on to a silver surface, while sodium fluoride, sodium sulphate, sodium carbonate and sodium nitrate did not.

Five solid detergents were tested in a similar manner, and all but one produced stains. These detergents all contained halides, but the one which did not cause stains had the lowest halide content. Thus it became evident that the active agents of stain formation were probably those halide compounds which would give insoluble silver halides, that is, the chlorides, bromides and iodides.

From a practical point of view stains may be formed both by salt or detergent particles falling

through washing-up water on to the silver. Those detergents which are solids and which contain chloride, bromide or iodide compounds will react in this way. Chemical tests showed that the stains formed by chlorides, bromides and iodides are composed of silver chloride, bromide and iodide, respectively, and it is probable that the dark colour is due to the degree of sub-division of the compounds.

It is quite likely that the increased occurrence of the stains in recent years is not only due to the fact that the solid detergents themselves can cause stains but also to the fact that by their use chemically clean surfaces are presented to any salt particles resting thereon, whereas previously most silverware was no doubt protected by a thin film of grease which prevented actual contact of the solution with the metal.

Strictly speaking, it is not necessary to have *solid* particles resting against the silver surface; a drop of strong salt solution pipetted on to the surface will cause a stain readily. The essential requirement for stain production is a local concentration of the halide at the silver surface and, as will be seen later, this promotes the formation of a half-cell of different potential from that existing elsewhere on the surface of the article. Electrochemical action then proceeds and a stain is formed.

Mechanism of Stain Formation

Let it be assumed that a piece of silver sheet be immersed in a very dilute chloride solution. No silver ions are present to begin with in the solution, and there is, therefore, no immediate equilibrium. As the silver ions enter solution the layer immediately adjacent to the silver surface becomes enriched in silver ions. The potential difference existing between the metal and solution will not have attained a steady value under such conditions. However, the point is reached when the concentration of silver ions is such that silver chloride is just precipitated. Any further increase in silver ion concentration will then no longer be possible, and the electrode potential will have reached a steady value.

Suppose now that the original solution contains a high concentration of sodium chloride. As silver ions begin to pass into solution they are complexed with the formation of sodium silver chloride:

$$Ag^+ + 2NaCl \rightarrow NaAgCl_2 + Na^+$$

This process will continue until there is an insufficient sodium chloride concentration at the metal surface to maintain the solubility of silver chloride, which is then just precipitated. The potential is now constant; but the attainment of this final steady value has involved the passage into solution of a much greater number of silver ions than in the previous case. Hence there is a more negative charge per unit area on the metal, and therefore a more negative potential. Actual experimental figures showed the potential of silver in almost saturated sodium chloride solution to be 0·04 volt more negative than in an extremely dilute chloride solution. Considered separately, neither of the two cases will produce any visible change in the appearance of the silver because the number of silver atoms involved is low. If, however, the two pieces of silver are connected, or are two adjacent areas of the same piece, then a cell is set up with electrons flowing through the silver from the area adjacent to the strong solution to that adjacent to the weak solution. The first area will serve as anode to the cell and the second will be the cathode. It may be assumed that the complex compound of sodium silver chloride is dissociated to some extent:

$$NaAgCl_2 \rightleftharpoons Na^+ + (AgCl_2)'$$

The loss of electrons from the anode permits the passage into solution of more silver ions which may then react as follows:

$$Ag^+ + (AgCl_2)' \rightarrow 2AgCl$$

thus producing the visible stain.

The above conditions are, of course, produced when a particle of salt falls through water on to a silver surface. The different concentrations must exist for electrolysis to proceed, and this electrolysis will proceed faster in solutions having a higher conductivity and also in those solutions containing ions readily reduced at the cathode. For example, the stains are more pronounced when salt particles are allowed to fall on to silver immersed in dilute sulphuric acid, in alkaline solutions or in solutions containing certain oxidants. The temperature of the solution also influences the conductivity and solubility factors involved, with the general result that the hotter the solution the more pronounced the stains. The mechanism of stain formation just described has assumed, for simplicity, that the local concentration of sodium chloride is the active factor in complex formation, but most chlorides, bromides and iodides will act similarly. Fluorides, however, will not cause stains on account of the very high solubility of silver fluoride.

Some simple tests may readily be performed to show the darkening effect on silver when subjected to anodic conditions in halide solutions. Thus, if a direct current be passed through two silver electrodes in a sodium chloride solution, the anode immediately darkens, silver chloride being formed.

Likewise a similar stain may be produced without applied direct current if a compartment cell is set up having a hot strong sodium chloride solution in the anolyte compartment, and a weak sodium chloride solution in the catholyte compartment. If the two silver electrodes are then connected externally, and a dilute solution of silver sulphate introduced adjacent to the cathode, a silver chloride stain is immediately formed on the anode.

This latter experiment is typical of the way in which stains are actually formed in practice, although the cathode reaction depositing silver may not always occur, particularly when certain oxidants are present in the solution.

It would thus appear from the foregoing work that if a reagent will form a relatively insoluble compound of silver which is soluble in excess of the reagent to give a complex, then a local concentration of that reagent will cause anodic corrosion and staining at the metal surface. This generalization is confirmed by the fact that silver is stained similarly by sodium cyanide and thiocyanate.

Application to other Metals

The mechanism of this anodic stain formation suggested that it would apply to some other metals in addition to silver. Tests were carried out on copper, and it was found that local concentrations of cyanides, chlorides and iodides produced corrosion and staining in the same manner, with the formation of a copper cyanide, chloride and iodide film, respectively. Similar-

ly, local concentrations of iodides stained lead, while cyanides had the same effect on cadmium and zinc.

Precautions to avoid Stains on Silver Tableware

To prevent the formation of stains during washing up it is necessary to preclude the possibility of local halide concentrations at the metal surface.

Thus the silverware should be washed first to avoid the risk of salt particles falling on to it from dinner plates. It would also appear advisable to avoid the use of *solid* detergents, but if they should be used it is essential to dissolve them completely before immersing the silver.

The adoption of these suggestions should prevent, almost completely, the occurrence of staining. However, it is still possible that stains may be formed occasionally when forks, etc., with particles of salt adhering are immersed in the water.

Removal of Stains

As previously stated, the normal methods of silver cleaning are not effective in practice with this type of stain. Although no quick and easy method of stain removal has been found, it is possible to effect removal by immersing the silverware in a hot strong salt solution. The stain will become lighter in colour and is then more easily polished to match the surrounding area. It is rather strange that a substance causing the stain in the first place may be used afterwards as a cleaner. In the stain removal process the salt solution should be well mixed to a uniform concentration. Chemical solution of the stain then proceeds, but electrochemical action also sets in. At the metal surface in the area of the stain there is formed a relatively high concentration of the $NaAgCl_2$ complex, hence a lower sodium chloride concentration and therefore a higher silver ion concentration compared with the rest of the surface. Consequently this area becomes cathodic and deposition of silver occurs, while in the surrounding anodic areas silver passes into solution. This loss of silver is, of course, small and is spread over a large area, but slight darkening of the area due to the attack may be just noticeable, and if so is easily removed by a rouge type of cleaner. The silver cathodically deposited in the stain area is similarly polished until it matches the other surfaces. It is probable that this mechanism of stain removal occasionally sets in immediately after stain formation and produces the white type of stain so frequently observed. In this case it is possible that agitation of the solution causes the dispersal of the local salt concentration and hence the reversal of the electrode polarities.

Practical experiments were performed to support the existence of electrochemical action in the stain removal process. For example, when freshly prepared silver chloride rests on a smooth silver surface immersed in hot sodium chloride solution for a short time, it is found, after rinsing, that metallic silver particles adhere to the surface on the areas where the precipitate had rested, while the surrounding areas are slightly darkened due to anodic corrosion.

An alternative stain remover is ammonia solution. This quickly dissolves the stain; but the area remains fairly dark due to the roughness of the underlying corroded metal and, therefore, this method is not recommended.

We are indebted to the directors of the Sheffield Smelting Co., Ltd., for permission to publish the results of these investigations. We also wish to acknowledge the help of the British Non-Ferrous Metals Research Association on stain identification by electron-diffraction methods.

THE INTERNATIONAL GEOLOGICAL CONGRESS

MEETING IN MEXICO

THE XXth Session of the International Geological Congress held in Mexico in 1956 was the largest gathering of geologists that has yet taken place. It was widely representative. It was characterized by an ease of interchange and co-operation, between all the national delegations, to a degree not attained at the two previous post-war sessions. It was successful and productive. This account of the proceedings has been deferred in the hope of assembling and taking account of the complete reports of all the Commissions, since these record some of the most valuable products of the Session. A number of them has lately been received; although some are not yet to hand, an appreciation of the Session and of the complex labours and generous hospitality of the Mexican hosts should be no longer delayed.

The programme began in the middle of August and lasted until October. The sessional meetings took place in Mexico City during September 4–11. Sixteen geological excursions before the meetings and sixteen afterwards, with places for two thousand participants, traversed all the Mexican States. Well over two thousand members attended the Session; eighty-three countries were represented. Some nine hundred papers were offered for presentation and pre-printed in abstract. There were thirty-six separate series of meetings—of the Bureau, Council and Commissions, symposia and subject sections, the International Paleontological Union and the Society of Economic Geologists. There were often twenty or more meetings in simultaneous progress.

The inaugural general assembly was held in the National Auditorium on September 4. Prof. Charles Jacob, president of the XIXth Session held in Algiers in 1952, took the chair until the election of his successor. The Assembly was welcomed by the President of the Republic of Mexico, Don Adolfo Ruiz Cortines, and by the Secretary of National Economy, Lic. Gilberto Loyo. Ing. Antonio García Rojas, director of exploration of Petroleos Mexicanos, was elected president of the XXth Session; and Ing. Eduardo J. Guzmán of Petroleos Mexicanos and Dr. J. González Reyna of the Geological Institute of the National University were elected general secretaries. The president and secretaries had held corresponding offices in the executive committee responsible for the organization of the Session.

All the subsequent meetings of the Session took place in the huge and fiercely brilliant buildings of the new National University, built in the past few years on a vast site eight miles from the centre of the capital.

Five symposia were organized. In published form, two of them, each in five volumes, will continue the Congress series of works on the geology and world resources of important minerals: "Oil and Gas Deposits", edited by E. J. Guzmán, and "Manganese Deposits", edited by J. González Reyna. Two stratigraphical symposia were promoted by the Commission on Stratigraphy, namely, "Cambrian Palæogeography and the Base of the Cambrian System", edited in three volumes by John Rodgers, and "The Cretaceous System and its World Correlations", organized by Lewis B. Kellum. The first three of these symposia were printed or in the press at the time of the Session. That on the Cretaceous system will be printed later, as will also a symposium on geochemical exploration which was organized by T. S. Lovering. In this, sixty-two papers presented at the Session showed the progress of many methods of exploration, including new field techniques for trace analyses of tin and selenium in soils, the application of geochemical soil surveys in the search for copper, gold and uranium, and reconnaissance for base-metal deposits by sampling drainage systems. In connexion with this symposium, the Council of the Session agreed to a proposal by L. R. Lambert (France) for the adoption of a universal scale based on the solar spectrum for colours on geochemical maps.

The Commission on the International Geological Map of the World, under the presidency of M. F. Blondel (France), reported substantial progress in the preparation of an International Geological Atlas, scale 1 : 10,000,000, and of co-ordinated regional maps of the world on the scale of 1 : 5,000,000. Dr. M. S. Krishnan (India) has served as co-ordinator for Asia since 1954; the Commission for the Geological Map of Europe, under the presidency of Dr. A. Bentz (Germany), has collaborated for Europe; and revised maps of Africa and North America are in hand. The work for South America is less advanced. Following propositions in Mexico by the Soviet delegation, the Commission undertook preparatory work for an international tectonic map and an international metalogenetic map.

The Association of African Geological Surveys and the Commission on the Geological Map of Africa were merged at the Session. In future, the Association will continue the functions of both, with the rank of a Commission. Most African territories were represented at meetings of the Association. Prof. P. Fourmarier (Belgium) was elected honorary president, and Dr. F. Dixey (United Kingdom) as president. In discussions on the geochronology of Africa, an outstanding paper was presented by Prof. Arthur Holmes (United Kingdom) and L. Cahen (Belgian Congo). Proofs of a structural map of Africa (1 : 10,000,000) by R. Furon and G. Daumain were examined. It was agreed that for its meeting in Africa in 1958 the Association should prepare a report on the geology of uranium in Africa, under the direction of G. Dubois (Belgian Congo).

The Commission on Gondwanaland met with Dr. S. H. Haughton (South Africa) as president and Dr. J. C. Mendes (Brazil) as its new secretary, and discussed a series of papers, some highly controversial. An overall impression was the increasing amount of evidence which suggests that the separate parts of Gondwanaland are in their original positions and have not been subjected to continental drift; though by no means all the contributors would be prepared to admit this.

Dr. M. H. Hey (United Kingdom), secretary of the Commission on Meteorites, of which Dr. W. Campbell Smith (United Kingdom) is now president, reported that the Commission had agreed to proposals by Y. L. Krinov (U.S.S.R.) for extending its work of preparing a census of meteorites and of disseminating information on existing collections and new occurrences.

The Commission on Stratigraphy, with Prof. R. C. Moore (U.S.A.) as president, Prof. P. Pruvost (France) as vice-president, and Prof. John Rodgers as secretary-general, was commended by the Council for valuable progress in the production of the lexicon of stratigraphy, under the secretaryship of M. Jean Roger (France), and for its work on stratigraphical terminology under the secretaryship of Dr. H. D. Hedberg (U.S.A.).

Prof. P. Fourmarier (Belgium), as president of the Commission on the Crust of the Earth, reported progress in the compilation of a lexicon of tectonic terms.

The Commission on Author's Abstracts was dissolved because its objects had been substantially achieved. The Commission on the International Physiographic Map of the World was dissolved at the proposal of its president, Dr. Louis S. Ray (U.S.A.), because it had been found impossible to obtain sufficient international agreement on the criteria for physiographical regions.

The Commission for the Spendiarov Prize, which was endowed in Russia in 1897 and is awarded at each Session, met with Prof. D. I. Scherbakov (U.S.S.R.) as president and nominated Dr. Manuel Alvarez, jun., to receive the Prize for the XXth Session, in recognition of his geological work in Mexico.

At the meetings of the International Paleontological Union, the principles of a new constitution were determined and it is now being drafted. Dr. M. Maldonado-Koerdell (Mexico) is the new president, and M. Jean Roger (France) is secretary.

Dr. H. M. E. Schürmann (Holland) submitted to the Council a plan for the initiation of an International Geological Abstracting Service as a self-supporting but non-profit making organization, analogous to existing services in medical and chemical fields. A small permanent commission, with Dr. Schürmann as president, was set up to promote this project. Following a report from the provisional French organizing committee set up in Algiers in 1952 under the presidency of M. G. Drouhin (Algeria), it was agreed that a permanent International Association of Hydrogeologists should be formed. On the proposal of Dr. G. Salas (Mexico), a Commission on Geological Nomenclature in Spanish was set up to standardize terminology in that language.

The number and variety of the papers presented at the subject sections were immense. A balanced review is not practicable here, but a few particular papers can be mentioned. There were several interesting contributions from Great Britain. In the Section on the Relation between Tectonics and Sedimentation, Mr. N. L. Falcon described the structural picture of south-west Persia which had emerged during forty years of work by geologists of the Anglo-Persian and Anglo-Iranian Oil Companies,

and showed the tectonic effect of phases of evaporite deposition in early Cambrian and in Miocene times. He exhibited a first copy of an impressive folio of geological maps and sections of the area, prepared for publication by the British Petroleum Company, and dedicated to the late Dr. G. M. Lees. The folio presents the essential results of the geological work of the earlier companies in the form of six maps with overlays on the scale of 1 : 1,000,000 and eleven sheets of cross-sections and stratigraphical columns. In the Section on Micropalæontology, Dr. Maurice Black described an investigation of the constituents of *Globigerina* ooze by means of mechanical analysis and the electron microscope. The size-frequency curves of the coarser fractions show numerous peaks representing different assemblages of foraminifera. Coccoliths and rhabdoliths predominate in the finer visible fractions, and the electron microscope shows the breakdown of some of these forms into minute particles of calcite which form the finest fraction of the ooze. In the Section on Cenozoic Vulcanicity, Profs. G. Mueller and S. E. Hollingworth gave an account of field and petrological work on sulphur deposits in Chile, Southern Europe and Iceland, including a laboratory study of the crystallization of sulphur melts as thin films which throws light on conditions during the formation of natural melts.

A good many papers dealt with new or improved methods and techniques. In the Section on Geology applied to Engineering and Mining, for example, E. B. Burwell, jun., and R. H. Nesbitt described the development by the U.S. Army Corps of Engineers of a camera for cylindrical colour photography in 3-in. boreholes, and its use in foundation problems. In the Section on Marine and Submarine Geology there were two papers, by R. F. Dill and by W. F. Tanner, on the study of sea-floor environments and sediments by 'free-diving' geologists.

A particularly notable paper in the Section on General Geology was "The Myth of the Sudbury Lopolith", by J. E. Thomson and Howell Williams—a vivid interpretation of this great structure as a volcano–tectonic sink.

It was generally agreed that the number of papers now received at each Session of the Congress is excessive, and that far too many are of only local interest. To some extent the breadth of the subject titles is responsible. The title of the Section on Palæontology, Taxonomy and Evolution, for example, embraces every possible palæontological topic. Only a selection of the papers can be read and discussed; but even so, the proceedings of most sections become unfocused, and the problems of publication unwieldy. During discussion of these matters by the Council, the Mexican hosts expressed the intention to publish, as a matter of international courtesy, practically all the papers which had been submitted to them. They no doubt had in mind the Report of the XIXth Session in Algiers, which totals 6,000 pages. That Report stands as a magnificent feat of publication, but can be a deterrent to potential future hosts of the Congress if it comes to be regarded as a precedent which they must emulate as an obligation or for prestige. The present writer believes it essential in future Sessions to reduce the scope of each section and define its object closely, and to reduce both the number of sections and the number of papers read in each. The organizers must feel free to reject all papers which are not of general interest and specific relevance, and to adhere to a maximum total length for the whole report which is compatible with their particular financial and editorial resources. Reduction in the number of sections would give time in the programme of the Session for the presentation and full discussion of certain major authoritative contributions, arranged by special invitation, on the lines proposed by E. Wegmann and D. Schneegans in 1948 (Report of the XVIIIth Session, Part I, p. 175; 1950).

The Council received a most welcome though embarrassingly large series of invitations for the XXIst Session: from the Scandinavian countries jointly, including Finland and Iceland; and from India, from Venezuela and from Western Germany. The invitation from Scandinavia was accepted, subject to formal confirmation by the five governments. This confirmation has lately been announced. The invitation was presented at the Session by Dr. T. Sorgenfrei of Denmark and supported by Prof. T. F. W. Barth of Norway, who also spoke for Sweden. It was particularly welcomed as the first co-operative regional invitation to the Congress. The Session will be centred on Copenhagen. Mr. H. E. Fyfe presented on behalf of the Government of New Zealand an invitation to hold the XXIInd Session in that country in 1964, in conjunction with the centenary of the foundation of the Geological Survey of New Zealand. The invitation was welcomed and recommended for the consideration of the Council of the XXIst Session.

Among many interesting items in an exhibition arranged at the University City during the Session were the folio of maps of south-west Persia which has already been mentioned, and an elaborate and instructive series of oilfield models in transparent plastic, prepared by Petroleos Mexicanos. The most extensive exhibit was a series of geological maps of the U.S.S.R. These, fine examples of colour-printing, covered the whole of the Soviet Union on scales of 1 : 5,000,000 and 1 : 2,500,000. There were also regional maps and various special-purpose maps on 1 : 1,000,000 and larger scales. In Mexico City, the exhibited collections of the Instituto Geologico were specially re-arranged for the Session. They include a handsome series of Mexican minerals, and collections of Mesozoic and Tertiary fossils, among which is a particularly fine group of Liassic plants. The Instituto Geologico building, a magnificent period piece, was built in readiness for the Xth Session of the Congress, in 1906, which was attended by 321 members from thirty-four countries. Exhibitions were also arranged on the routes of some of the excursions; among these, there was at Cordoba an admirable exposition of oilfield research by the staff of the Vera Cruz Division of Petroleos Mexicanos.

The programme of field excursions as a whole illustrated clearly the great progress in knowledge of the geology and mineral resources of the Mexican States which has been made in recent decades. The programme involved elaborate organization, large parties, great distances, and transport by horse, boat and ferry, lorry and coach, special train, and aircraft. Inevitably there were hitches here and there, but many excursions were commended by participants as outstanding demonstrations of aspects of Mexican geology. There was opportunity on the excursions to study the massive grim beauty and sardonic detail of Aztec and Mayan architecture—and the reflexion of its qualities in some of the most modern Mexican buildings. Over all on the excursion routes, there was the enduring impression of endless variety in the

permutations of topography, geology, climate, ecology and human works which make up the Mexican scene.

In Mexico City and on the excursions, hospitality on a most generous scale was arranged by central and local government authorities and by industry. The functions in the capital included a reception at Chapultepec Castle, a programme of traditional dances of the Mexican States in the National Auditorium, ballet in the Palace of Fine Arts, and a rodeo at the Rancho del Charro. This generosity of official entertainment was matched by the warm personal hospitality and helpfulness of Mexican geologists and their families.

A. J. Butler

THE NATIONAL MUSEUM OF WALES

By The Right Hon. LORD KENYON
President of the Museum

MARCH 19 marks the jubilee of the granting of the Royal Charter of incorporation to the National Museum of Wales by King Edward VII, and we are glad of the opportunity to assess what has been achieved in these past fifty years, and summarize our plans for the future.

The idea of a national museum for Wales arose as far back as 1876, in a paper read before the Honorable Society of Cymmrodorion, by which it was discussed from time to time. The matter was even raised in Parliament occasionally, until in 1903 a parliamentary conference was convened to discuss the formation, nature and location of a national museum and a national library for Wales. After discussions, petitions and speeches, the decision was reached to place the National Museum at Cardiff: for reasons which did not affect the Museum, the Library was placed at Aberystwyth.

The charter, besides bringing the Museum into being as an incorporated body, describes its objects, and the method by which it is to be governed and administered. The article describing its object is both long and comprehensive; it may be simply stated as to illustrate the natural history of Wales, and the life of man in it, both in the past and to-day.

In the following year, the first director, Dr. William Evans Hoyle, was appointed, beginning his task on St. David's Day, 1909. He was soon touring the museums and galleries of northern Europe to gather experience for the planning of the new buildings, for which an open competition, attracting no less than one hundred and thirty designs, was held. This culminated in the appointment of Messrs. Smith and Brewer in the following year. Constructional work began in 1911: it was continued, punctuated by constant financial and other set-backs, for more than twenty years; and the foundation stone was formally laid by King George V, accompanied by Queen Mary, in 1912. It was not, however, until ten years later, owing to the intervention of the First World War, that the first part of this building became accessible to the public, and a further five years elapsed before Their Majesties again visited Cardiff, on the completion of the whole south front of the building, for the opening ceremony.

Construction, however, continued on the east wing, which includes the lecture theatre and circular gallery, which were opened by the Duke of Kent in 1932; there building has had to cease, the architects' plans only half-completed, until funds permit a recommencement. The total cost, so far, has been £429,744, of which £232,692 has been received in gifts and subscriptions, both large and small, and including much generous help from Cardiff City Council.

The collections contained in this building had, as their nucleus, the contents of Cardiff's Municipal Museum, the Welsh Museum of Natural History, Arts and Antiquities, which were transferred to the National Museum in 1912, although continuing to be shown in the Free Library until the building was able to receive them ten years later. These "Cardiff Collections" contained something for most of the departments into which the Museum is now divided.

Between 1914 and 1919, Departments of Geology, Botany, Zoology, Archæology and Art were set up with the appointment of a keeper or an assistant keeper in charge, and these five Departments still occupy the main building in Cardiff. In 1924 Dr. Hoyle retired, and was succeeded by Dr. (now Sir) Mortimer Wheeler, who departed for a post in London two years later. His successor, Dr. (now Sir) Cyril Fox, remained to direct the Museum until his retirement in 1948, when his place was taken by Dr. D. Dilwyn John.

One further Department has occupied the galleries in Cardiff, but is now elsewhere. In 1932, a sub-Department of Folk Culture and Industries was added to the Department of Archæology, in order to cater for the rapid growth in that Department's collections relating to the trades and crafts, the domestic environment, and the daily life of the past in Wales. Four years later it was raised to the status of a Department, when the Council affirmed its conviction that an Open Air Folk Museum was an essential development of the National Museum. This was achieved in 1946, through the generosity of the Earl of Plymouth, who presented St. Fagans Castle, near Cardiff, to the Museum for this purpose. At the same time, he permitted the acquisition of 80 acres of adjoining woodland, which has made possible the planning and establishment of a collection of typical buildings of all sorts from every part of the Principality. These at present include farm-houses of characteristic type, a working woollen mill, a chapel, a barn, and a one-roomed cottage; more will be added as opportunity offers. The rooms of the Castle itself are furnished from the Museum's collections to illustrate the styles of various periods, while the gardens and grounds are maintained as a setting for the buildings. The outbuildings accommodate craftsmen at work at turnery, basketry, and other country crafts; in the Mill, the workmen will be found employing machinery which has been in use for more than a hundred years. More recently, a small beginning has been made on the erection of a modern museum block needed to house the Folk Museum's ever-growing collections and to display its type col-

lections; here, as in Cardiff, lack of funds precludes more rapid progress.

Space will not permit a detailed description of the growth of the five departments housed in Cardiff. Suffice it to say that the aim has been to meet, in the first place, the needs of the casual visitor, by means of planned and attractive exhibits, designed to be of general interest. At the same time, collections have been amassed which are capable of satisfying the requirements of students and research workers, partly through the generosity of private collectors and donors, partly from expeditions and excavations sponsored by the Departments themselves.

Such expeditions are not the only contacts which the Museum has beyond its own boundaries. The Turner House, Penarth, erected by James Pyke Thompson in 1888, in order to share his collection of pictures with the public, was transferred to the Museum by his trustees in 1921, for use as a branch art gallery, and now houses a constantly changing succession of loan and travelling exhibitions. A still older collection merged with the National Museum when, in 1930, at the invitation of the Monmouthshire and Caerleon Antiquarian Society, responsibility was accepted for the museum at Caerleon, built in 1850 to house local antiquities, and in which it now shares with the archæological galleries at Cardiff the fruits of the excavations of the legionary fortress in which the Museum has had a constant interest over many years, as it has also had in excavation elsewhere in Wales.

In two further ways, the Museum, its staff and its contents are becoming known throughout the Principality. In 1922, a scheme of affiliation was inaugurated for the smaller museums which are scattered throughout Wales. The first of its kind in the British Isles, its benefits may be seen in almost every county in Wales.

Not content, however, with making its services available to other similar institutions in Wales, in 1949, with the financial assistance of local education authorities, the Museum Schools Service was inaugurated, to provide for the extension of the hitherto restricted services available to schools in Wales. With the active support of every authority, the Service has grown in a short time to include an officer in each of the five Departments in Cardiff, with some three thousand portable exhibits being distributed to schools throughout Wales every term. Arrangements are also made for the reception and guidance of school parties at the Museum, and it is gratifying that the number of these parties is growing every year.

The Museum's collections have been enriched by many generous gifts and benefactions: the extent of this debt can never be accurately measured. Space will, however, only permit mention of one, itself of such distinction that it transformed the Department of Art into a gallery of international importance. This was the bequest of Miss Gwendoline Davies of her notable collection of pictures, drawings and sculpture. Particularly strong in the paintings of the nineteenth century in France, it also includes notable works of all ages from Botticelli to Augustus John.

Of all the objects envisaged by the charter, one only remains to be realized: a department to illustrate the industries of Wales and their impact on its life, both yesterday and to-day. In recent years the Treasury has been asked for the funds necessary to start such a department, but has so far been unable to make them available. Only when a Department of Industry is created will the terms of the charter be fully implemented, and all the reasonable requirements of the public be met.

Much, of course, remains to be done elsewhere. The building in Cardiff is only half-complete; development at St. Fagans must be maintained if the Folk Museum's objective of preserving as much as possible of the buildings and the environment of Welsh life, both past and present, is to be achieved. During the past fifty years, growth and development have been constant and steady. The Museum is prepared for the future in every respect but that of finance, where, in common with the majority of museums in the British Isles, the position causes the gravest misgivings. But, whatever may be in store, we can be sure that with the loyal service we have come to expect from the staff, and the continued assistance of so many throughout Wales, the Museum can look forward with confidence to the future.

OBITUARY

Prof. Henry Norris Russell, For.Mem.R.S.

Henry Norris Russell, whose death at Princeton after a long illness was reported in February, was born at Oyster Bay, New York State, on October 25, 1877. He graduated Ph.D. at Princeton University in 1900, and in 1903 he went to King's College, Cambridge, as a research assistant of the Carnegie Institution; he worked on photographic stellar parallaxes with A. R. Hinks at the Cambridge University Observatory. On returning to Princeton he held various minor posts there; in 1911 he became professor of astronomy at Princeton, and in the following year director of the University Observatory, a post he held until 1947. In 1927, by which time he had established his position as one of the foremost theoretical astrophysicists in the world, he was appointed research professor of astronomy; at the same time he was made a research associate of the Mount Wilson Observatory. He resigned his chair in 1947 and was then made research associate of the Lick and Harvard Observatories.

As early as 1912 Russell began publishing papers on eclipsing binary stars, a subject which was to interest him all his life. His last few published papers were devoted to eclipsing binaries, and one on "Eclipsing Variables in the Magellanic Clouds" was published in "Vistas in Astronomy" (Vol. 2) only a week before his death. His early work also included studies of the orbits of spectroscopic binaries and of the origins of binary stars. His work on stellar evolution, remembered everywhere in the Russell–Hertzsprung diagram, gained for him the Gold Medal of the Royal Astronomical Society in 1921. Russell next became interested in ionization in solar and stellar atmospheres and in spectroscopic problems linked with multiplets and series in atomic spectra, with special reference in iron and titanium. Improve-

ments in multiplet notation and the Russell–Saunders coupling are abiding results from his work in this field.

Russell was also working actively on the composition of the solar atmosphere, on the pressures at the Sun's surface and on the principles to be employed in the analysis of stellar spectra. He was concerned along with others in stellar classification, in spectroscopic and trigonometrical parallaxes and in the calibration of Rowland's scale of intensities in the solar spectrum. The width of his interests is indicated by the fact that he served on no less than eleven commissions of the International Astronomical Union; he was president for several terms of the Commission on Stellar Spectra and later of the Commission on the Constitution of the Stars. Up to some fourteen years ago he was actively contributing important papers on a wide range of astrophysical subjects; in his latest papers he reverted to his early interest in eclipsing binaries.

In addition to his many scientific papers, he published books on "Stellar Parallaxes", "The Solar System and its Origin", "The Masses of Stars", "Fate and Freedom", and in 1926 (with R. S. Dugan and J. Q. Stewart) a text-book on astronomy which has been for years the standard work on the subject. His researches were recognized by many awards. In his own country he was given the Henry Draper Medal (1922), the Bruce Medal and the Rumford Medal (1925) and the Franklin Medal (1934). France awarded him the Lalande Prize in 1922 and the Janssen Medal in 1936. He was elected an associate of the Royal Astronomical Society in 1916, foreign member of the Royal Society in 1937, a corresponding member of the Paris Academy of Sciences in 1939 and an honorary member of a number of other foreign academies. He was elected an Honorary Fellow of King's College, Cambridge, in 1941. He was president of the American Association for the Advancement of Science in 1933. A man of overflowing energy, never sparing himself in his own work or in assisting the researches of others, he was the most eminent and versatile theoretical astrophysicist in the United States, if not in the world. F. J. M. Stratton

NEWS and VIEWS

Mechanical Engineering at University College, London: Prof. B. J. Lloyd-Evans

Prof. B. J. Lloyd-Evans is to retire at the end of this session from the Kennedy chair of mechanical engineering at University College, London—a post which he has occupied since the retirement of the late Prof. G. T. R. Hill in 1948. His long and devoted service to the Mechanical Engineering Department dates back thirty-seven years, during which time he has lectured mainly on applied thermodynamics and hydraulics, and has been in charge of the workshop and mechanical engineering laboratories. Dr. Lloyd-Evans is an honours graduate of the University of London. Among his duties when first appointed as senior lecturer under the late Prof. E. G. Coker were the extension and reorganization of the workshop and the establishment and equipment of the Hawksley hydraulics laboratory. He acted as head of the Department during the War period when the Faculty of Engineering was evacuated to Swansea. After the return to London a considerable programme of modernization of equipment had to be undertaken. In spite of the heavy demands upon his time made by teaching and routine, he has carried out a good deal of original research. One of his subjects was the extinctien pyrometer technique for measurement of flame temperature in internal combustion engines, while, in conjunction with the Physics Department of the College, he worked on the development of high intensity electromagnets. Throughout his career, Dr. Lloyd-Evans has been distinguished for his ability as a teacher, his personal interest in his students and his friendliness with those who have been privileged to work with him.

Dr. R. E. D. Bishop

Dr. R. E. D. Bishop, lecturer in engineering at the University of Cambridge, has been appointed to succeed Prof. Lloyd-Evans. Dr. Bishop served during the latter part of the Second World War in the Royal Navy and entered University College, London, in 1946 under the Further Education and Training Scheme. He read mechanical engineering and took a first-class honours degree, the Diploma of the College (with distinction) and was awarded the Head Memorial Medal and Prize. Between 1949 and 1951 he held a Commonwealth Fellowship at Stanford University for study under Profs. J. N. Goodier and S. P. Timoshenko, and, while there, conducted research on elastic wave propagation. An appointment to a demonstratorship in engineering took Dr. Bishop to Cambridge in 1952. He was made university lecturer in 1955, having been admitted to a fellowship of Pembroke College in 1954. The Stanford school is specially strong in applied mechanics and, while there, Dr. Bishop became particularly interested in its various branches. He has since worked in this field, paying particular attention to the general wave motions of elastic bodies and, more recently, mechanical vibration. In the early stages of this latter work he collaborated at Cambridge with D. C. Johnson before his move to Leeds as professor of mechanical engineering. A book of vibration analysis tables recently appeared under their names and its preface states that they are producing a second book together. Dr. Bishop is a member of the Applied Mechanics Committee of the Institution of Mechanical Engineers.

Building Science at Liverpool: Prof. A. W. Hendry

More engineers and others with scientific training should be encouraged to enter the building industry, and more than a veneer of science is needed in architectural courses. The University of Liverpool, which has a strong Faculty of Engineering and School of Architecture, as well as a special section of the Department of Physics which deals with acoustics, has therefore created a new chair of building science. Prof. A. W. Hendry is to be the first holder of this chair. He initially graduated in the University of Aberdeen. After gaining practical experience with Sir William Arrol and Co., Ltd., Glasgow, he returned to lecture at Aberdeen for six years. For two further

years he held a readership at King's College, London, and then in 1951 became professor of civil engineering and later dean of the Faculty of Engineering in the University College of Khartoum. In these capacities he has been studying the relationship between civil engineering and architecture and has been instrumental in starting a Department of Architecture, within the Faculty of Engineering, at Khartoum. Prof. Hendry is well known in Britain for his work on photoelastic stress analysis of structures, and load distribution in interconnected frameworks. His breadth of outlook should be of considerable value to him in speeding the scientific renaissance in building and architecture in Britain.

Royal Society of Edinburgh: New Fellows

THE following have been elected Fellows of the Royal Society of Edinburgh: Dr. G. O. Aspinall, lecturer in the Department of Chemistry, University of Edinburgh; Prof. A. J. Beattie, professor of Greek, University of Edinburgh; Dr. W. Bolton, principal scientific officer, Poultry Research Centre, Edinburgh; Prof. J. H. Burnett, professor of botany in the University of St. Andrews; Dr. W. A. Clark, lecturer in the Department of Botany, King's College, Newcastle; Dr. G. E. R. Deacon, director, National Institute of Oceanography; Dr. J. M. Dodd, lecturer in zoology, University of St. Andrews (in charge of the Gatty Marine Laboratory); Dr. A. T. Doig, H.M. Deputy Senior Medical Inspector of Factories, Ministry of Labour and National Service; Dr. J. W. Gregor, director, Scottish Plant Breeding Station; R. A. Hamilton, senior meteorological officer, Prestwick; Dr. H. Lees, lecturer in the Department of Biological Chemistry, The University, Aberdeen; D. N. Lowe, secretary to the Carnegie United Kingdom Trust, Dunfermline; J. Macdonald, director of research and education, Forestry Commission, London; Prof. J. W. McLeod, emeritus professor of bacteriology in the University of Leeds; Dr. A. C. G. Menzies, director of research, Hilger and Watts, Ltd., optical instrument manufacturers, London; Dr. C. H. Mortimer, secretary of the Scottish Marine Biological Association and director of the Association's Marine Laboratory, Marine Station, Keppel Pier, Millport, Isle of Cumbrae; A. Nisbet, lecturer in mathematical physics and director of studies in arts and science, University of Edinburgh; Dr. E. M. Patterson, Research Department, Imperial Chemical Industries (Explosives Division), Ltd.; Prof. S. Piggott, Abercromby professor of prehistoric archæology, University of Edinburgh; R. W. Plenderleith, assistant keeper, Department of Technology, Royal Scottish Museum; J. N. Ritchie, chief veterinary officer, Animal Health Division, Ministry of Agriculture, Fisheries and Food; Dr. S. M. Shah, reader in mathematics, Muslim University, Aligarh; Prof. F. H. Stewart, regius professor of geology and mineralogy in the University of Edinburgh; Prof. E. W. Walls, professor of anatomy, Middlesex Hospital Medical School; Dr. G. A. P. Wyllie, lecturer in theoretical physics, University of Glasgow.

National Agricultural Advisory Service: Appointments

THE following appointments in the National Agricultural Advisory Service have been announced: Mr. J. W. Reid, at present deputy provincial director at the South Western Provincial Sub-Centre, Starcross, is to be provincial director of the Yorkshire and Lancashire Province in succession to the late Mr. H. Trefor Jones. Mr. T. W. Williamson, deputy provincial director, at present chief adviser on rabbit destruction, will be returning to the Advisory Service and will succeed Mr. Reid at Starcross. Mr. W. E. Jones, who is at present temporarily filling the post of chief farm management adviser during the absence of Mr. Arthur Jones with the Organization for European Economic Co-operation, has been appointed director of the Advisory Service in Wales in succession to Mr. E. Ll. Harry. Mr. Harry has been appointed regional controller of the East Midland Region. Mr. H. E. Evans, at present county agricultural officer for Carmarthenshire, is to be deputy director for Wales at the Bangor Sub-Centre.

Research in Universities

IN his Perkin Medal address to the Society of Chemical Industry in New York on January 11, Dr. G. T. Seaborg said that by its nature and purpose the university is the natural centre for basic research, though the rising costs of research, particularly in the physical sciences, and the participation of private foundations, the National Science Foundation and other State and Federal agencies, have recently had a profound influence on the development of basic research. A generous supply of funds is not in itself sufficient: in the end, investing in basic research implies backing the investigator rather than the programme, and Dr. Seaborg urged that the universities need means to create more positions comparable with that of the professor with regard to freedom, prestige and tenure, whether or not formal teaching is entailed. He also urged more imaginative thought regarding increase in the service facilities available for the creative scientists and directed attention to the waste of man-power involved when a highly trained research worker spends hours rectifying faulty equipment which a competent technician could correct in a few minutes. He pointed out that it is the choice of the experiment and experimental techniques, and not the extent of the assistance required to build and service the equipment, which determines whether the individual's or some collective judgment is being exercised. The university graduate school, said Dr. Seaborg, is our most effective device for cultivating the intellectual powers of a potential scientific investigator and, stressing the difference between undergraduate and postgraduate work, he thought that the challenge to their skill and the development of their manual and mental powers would be a permanent asset to those trained in the graduate schools. He also suggested that, of the 5,000 million dollars a year spent in the United States by government, industry, universities and non-profit-making institutions, the 5–10 per cent at present devoted to basic research should be doubled as soon as possible, and noted that the Atomic Energy Commission has increased its budget for basic research by 50 per cent during the past two years.

The Perkin Centenary Trust

THE Trustees of the Perkin Centenary Trust, which was established to commemorate the discovery of mauveine by William Henry Perkin in 1856, have announced a number of awards to promote technical education in any aspect of the manufacture or the application of colouring matters. *The Perkin Centenary Fellowship* is offered for one or two years to a graduate for the purpose of higher study. It has a value of £600 per annum, and is tenable at any

university, technical college or other institution approved by the Trustees. Two *Perkin Centenary Scholarships* are offered, each for two years, renewable at the discretion of the Trustees for one further year, to enable candidates employed in an industrial firm or other institution concerned with the manufacture or the application of colouring matters to receive an education at a university or technical college. Each award will have a value of £300 per annum. There is no means test for the award, and a successful candidate is not debarred from receiving the whole or a part of his normal salary from his employers during his tenure of the Scholarship. Applications for either Fellowship or Scholarship must be submitted, on forms available from the Secretary to the Trustees, not later than May 1. *Perkin Exchange Lectureships:* a short-term appointment will be made from time to time by the Trustees to enable a senior teacher at any appropriate university, technical college or other institution to visit some similar establishment overseas in order to deliver a short course of lectures. In return, a visit to a British institution by some overseas scientist will be arranged. A longer-term appointment is also contemplated to permit the exchange of lecturers for a period of up to one year between comparable institutions in Britain and overseas.

The Trustees are Mr. H. Jackson (chairman), Dr. D. W. Hill, Dr. L. H. Lampitt, Mr. W. R. Mathers, Mr. M. W. Perrin and Sir Robert Robinson. The secretary to the Trustees is Dr. J. R. Ruck Keene, to whom inquiries relating to the above awards should be addressed, c/o The Chemical Society, Burlington House, London, W.1.

Investigations on Coast Erosion in Britain

In an adjournment debate on March 5 in the House of Commons the subject of discussion was coast erosion. Mr. N. Nicolson agreed with the Waverley Committee that the intensity of research in this field should be increased, and asked a number of questions about the activities of the Hydraulics Research Board; he also urged the Ministry of Housing and Local Government to make grants for maintenance and repair and for temporary first-aid to works of coastal defence, as it is empowered to do and as the Waverley Committee has recommended. Replying for the Ministry, the Parliamentary Secretary, Mr. J. R. Bevins, declined to comment on Mr. Nicolson's argument that sea-defences should be made mainly a national charge, beyond pointing out that there is no obligation on the central government to provide the full cost of such schemes and that this would require legislation. Nevertheless, the Treasury has been paying up to 85 per cent of the capital cost of coast protection works carried out by local authorities since the end of the War, and on average more than half. On research into coast protection problems, Mr. Bevins said that an advisory committee on sea defence research was set up two years ago which has issued two reports. One of these dealt mainly with embankments on estuaries and the other with the movement of beach materials; the Advisory Committee is at present considering the effect of vegetation.

European Organization for Nuclear Research

At a Friday Evening Discourse, delivered at the Royal Institution on March 8, Sir Ben Lockspeiser, who is president of the Council of European Organization for Nuclear Research (C.E.R.N.), said that the resources, human and material, required for scientific research have grown in some fields to large dimensions in recent years. This is particularly so in the field of nuclear physics where the means necessary for conducting experiments have increased beyond the single capacities of most nations. The European Organization for Nuclear Research (see *Nature*, **178**, 902; 1956) was, therefore, brought into being to enable twelve European countries to achieve together what they are unable to do alone. The first task of the Organization has been to provide itself with research tools, and two particle accelerators are being built at Meyrin, near Geneva: one, a 600-MeV. synchro-cyclotron, in which the path of the accelerated particle is a flat spiral, and the other, a 25-GeV. proton-synchrotron, which accelerates the particle in a repeated circular path. Sir Ben outlined some of the scientific and technological problems presented in the course of their design and construction. The present staff, drawn from various countries, numbers about three hundred. A multi-national venture of this kind requires its own form of organization to govern itself and to maintain essential relationships with the governments of member States. It requires also an administration capable of dealing with both the present constructional period and the succeeding stage, now beginning, when scientists from various countries will be enabled to use the machines for limited periods dependent on their programme of work.

National Institute for Research in Nuclear Science

The Chancellor of the Exchequer, in a written reply in the House of Commons on March 12, stated that the governing board of the National Institute for Research in Nuclear Science, under the chairmanship of Lord Bridges, has been constituted by the Lord President of the Council and himself, with the following representative members: *Universities:* Sir Philip Morris, Sir James Mountford, Prof. N. F. Mott, Prof. H. S. W. Massey, Prof. J. Diamond, Prof. R. E. Peierls and Dr. D. H. Wilkinson; *University Grants Committee:* Sir George Thomson, Mr. J. C. Gridley; *Royal Society:* Sir David Brunt; *Atomic Energy Authority:* Sir John Cockcroft, Sir Donald Perrott and Dr. B. F. J. Schonland; *Department of Scientific and Industrial Research:* Dr. H. W. Melville and Prof. P. M. S. Blackett.

New Reactor at Harwell

A new experimental low-energy reactor, NERO, is now operating at the Atomic Energy Research Establishment, Harwell. It became critical for the first time at 7.45 p.m. on February 23, and its experimental programme is now beginning. The reactor will be used to investigate the design problems associated with the more advanced types of graphite-moderated power reactors now under study by the Authority. The reactor consists of a graphite stack which can be varied in size up to a cylinder of about 14 ft. diameter by 10 ft. high within a concrete biological shield 2 ft. thick. Fuel elements of differing types may be arranged within the graphite stack in any one of a number of possible lattice patterns. The restacking of the graphite to permit a change in the fuel element arrangement can be done in a few days. The reactor is controlled by two vertical cadmium control rods which can be moved into the graphite stack through the top of the biological shield. Cadmium 'shut off' or 'safety rods' are

arranged to move into the graphite stack in a similar manner. The maximum thermal neutron flux is about 10^8 neutrons cm.^{2}/sec. and the heat output is restricted to less than a hundred watts.

The reactor will at first be used to check calculations on the effect of separating the fissile content of the fuel (for example, uranium-235 or plutonium-239) from the fertile content (for example, uranium-238); data of this kind are of importance for the design of reactors in which nuclear fuel may be recycled through the reactor. Another application of the reactor is to investigate problems associated with the design study of a sodium-cooled graphite moderated reactor. For this reason the name NERO is derived from the phrase 'Na (sodium) experimental reactor'. The 'O' is added to indicate that it is a zero-energy (that is, low-energy) reactor.

NERO was designed and built by an Atomic Energy Research Establishment team in association with the following industrial firms: Saben, Hart and Partners, Ltd., London, and Technical Design and Tool Co., Ltd., Reading (detail design work); Messrs. March, Ltd., Reading (steel work fabrication); R.O.F., Nottingham (roof trolleys); and H. M. Hobson, Ltd., Wolverhampton (control mechanisms).

The National Museum of Wales

THE forty-ninth annual report (1955–56) of the National Museum of Wales, after recording the usual formal matters, refers to the fact that the major part of the reorganization of the first-floor galleries has been completed. All folk-life material has been transferred to St. Fagans, archæology to the west and art to the east galleries. The circular gallery has thus been freed for temporary exhibitions, and the previous Welsh rooms are being converted to provide a print room and a small gallery for the Old Masters. Unfortunately, an application to the Treasury for funds to make provision for a Department of Industry was not successful in spite of frequent statements by the Government that technological education is an urgent need of our times. It is earnestly hoped that this matter will be reconsidered as soon as possible. The Department of Geology has made installations whereby temporary exhibits of maps and photographs can be prepared easily. The Department of Botany records the revision of various existing exhibits and the maintenance of the wild-plant table throughout the year. The Department of Zoology has prepared two new exhibits. One deals with the economic products of the cow, pig and sheep, while the other is concerned with British freshwater fishes. In the Department of Archæology the reorganization consequent on transference to the west galleries has been extensive, while a similar major rearrangement has taken place in the Department of Art. At St. Fagans the re-erection of Capel Pen-rhiw was completed and the chapel is attracting a record number of visitors. As usual, the staff of this live institution have been particularly active in research problems and many published works are listed. (See also this issue of *Nature*, p. 562.)

Fast–Slow Reactor at Harwell

HARWELL now has a fast–slow reactor, a simple modification having resulted in interesting changes to the characteristics of the fast reactor ZEPHYR. Graphite has been substituted for the uranium bars that originally formed the outer reflector. The thin inner reflector of uranium still surrounds the plutonium core. In its new form the reactor diverged with a critical mass of plutonium very close to that in the uranium-reflected system. Because the neutrons reflected back into the inner reflector have been slowed down, ZEPHYR now shows some of the characteristics of a thermal reactor. For example, experiments have shown that the chain reaction can now be controlled, as in a thermal reactor, by putting an absorber of slow neutrons such as cadmium into the graphite. It is too early to predict the applicability of this 'mixed' system to power breeder reactors such as that at present under construction at Dounreay.

International Symposium on Proteins

A SYMPOSIUM on protein chemistry is to be held in Paris during July 25–29 under the auspices of the Commission on Proteins of the Section of Biological Chemistry, International Union of Pure and Applied Chemistry. The programme will be devoted to a survey of present knowledge of the structure and biological function of protein molecules, and the papers will be published in monograph form. Inquiries and applications to register should be addressed, before April 1, to the chairman of the symposium, Prof. Jean Roche, Collège de France, Place Marcellin-Berthelot, Paris 5.

In connexion with this symposium and as an exploratory step towards determining the demand for internationally available standard samples of proteins, the Commission on Proteins has announced the present availability of a special sample of a single lot of beef insulin. Designated as crystalline beef insulin, Batch No. 2189, the protein has been tested by Craig's counter-current distribution method and Porter's chromatographic procedure. Copies of the curves thus obtained are supplied with each sample. The insulin is obtainable by writing to British Drug Houses, Ltd., Graham Street, City Road, London, N.1, and is packed in 1 gm. ampoules at £6 (18 dollars) to cover the cost of manufacture and distribution. The purpose in making this sample available is to provide a single lot of insulin to which different laboratories can turn in experiments where it may be of value to be using the same protein preparation. If reference samples of this type prove useful to protein chemists, the Commission on Proteins of the International Union of Pure and Applied Chemistry hopes to make available other single batches of proteins prepared in as pure a state as is practicable with current methods of commercial processing.

Comments on this programme will be welcomed and should be addressed either to the President of the Commission, Prof. A. Neuberger, Department of Chemical Pathology, St. Mary's Hospital Medical School, London, W.2, or to the Secretary, Dr. Stanford Moore, The Rockefeller Institute for Medical Research, 66th Street and York Avenue, New York 21.

Supply of *d,l*-Aldosterone

A LIMITED supply of *d,l*-aldosterone for biological and clinical investigation has been made available to the Endocrinology Study Section, National Institutes of Health, by CIBA Pharmaceutical Products, Inc., Summit, New Jersey. This synthetic racemic material has one-half the biological activity of the natural *d*-aldosterone. It is available to qualified investigators in the following forms: *d,l*-aldosterone 21-monoacetate—purified sesame oil solution—200 μgm./ml.; *d,l*-aldosterone 21-monoacetate—purified

sesame oil solution—20 μgm./ml.; *d,l*-aldosterone 21-monoacetate—95 per cent ethanol solution—1 mgm./ml.; and *d,l*-aldosterone (non-esterified)—95 per cent ethanol solution—10 μgm./ml. The monoacetate will be distributed for biological work and the non-esterified form limited to use as a chromatographic standard. The alcohol solution of the monoacetate can be diluted for intravenous injections. Purified sesame oil can be obtained from CIBA for those who have occasion to dilute the oil solutions. Requests should be made to Dr. R. T. Hill, Executive Secretary, Endocrinology Study Section, National Institutes of Health, Bethesda 14, Maryland, briefly stating the exact amount wanted and the nature of the investigation.

Aerial Photogrammetry

The École Nationale des Sciences Géographiques, which is part of the Institut Géographique National, is to hold a theoretical and technical course in aerial photogrammetry, intended for non-French students and photogrammetrists wanting to practise the instruments and methods currently used in France. It will be held at Saint-Mandé, near Paris, during June 24–August 2. Lectures will be delivered in French, with explanations in English and Spanish for those not familiar with the French language. The programme includes discussion of problems of aerial photogrammetry; aerial surveys; principles, construction and adjustment of plotting machines; problems concerning mean scale and small-scale plotting; and a newly elaborated method of aerial triangulation. The number attending is limited to twenty-five, and the fee for the six-weeks course is 20,000 francs. Applications for registration must be sent to the Director, École Nationale des Sciences Géographiques, 2 Avenue Pasteur, Saint-Mandé (Seine), before May 15.

University of London: Appointments

It has been announced that Dr. F. D. Richardson, Nuffield Fellow at the Imperial College of Science and Technology in the University of London, has been appointed to the chair of extraction metallurgy tenable at that College. The title of professor of theoretical physics in the University of London has been conferred on Dr. R. K. Eisenschitz in respect of his post at Queen Mary College; and the title of reader in agricultural botany in the University of London has been conferred on Dr. I. W. Selman in respect of his post at Wye College. Dr. W. B. Bonnor, lecturer in the University of Liverpool, has been appointed to the University readership in mathematics tenable at Queen Elizabeth College. The title of professor of hæmatology has been conferred on Dr. J. V. Dacie, and that of professor of clinical endocrinology on Dr. T. Russell Fraser in respect of the posts held by them at the Postgraduate Medical School of London.

Science Museum: Appointments

Dr. D. H. Follett has been appointed keeper of the Department of Electrical Engineering and Communications at the Science Museum, South Kensington, in succession to Mr. F. St. A. Hartley, who has just retired. Until his appointment, Dr. Follett was deputy keeper in the Department of Physics and secretary to the Advisory Council of the Science Museum. Mr. J. A. Chaldecott has been appointed to the posts vacated by Dr. Follett.

Announcements

The Hinchley Medal for 1956 of the British Association of Chemists has been awarded to Mr. H. L. Howard, and the formal presentation will be made at a meeting to be held at the Royal Society of Medicine on March 19. Mr. Howard will deliver an address on "Chemists and the Community".

Dr. V. G. W. Harrison has been appointed director of research of the Printing, Packaging and Allied Trades Research Association. He succeeds Dr. G. L. Riddell, who is leaving the Association to join Albert E. Reed and Co., Ltd., as head of their expanding Packaging Research and Development Division. Dr. Harrison, who is forty-five and has been with PATRA since 1937, has for the past nine years been in charge of the Association's optics laboratory.

A summer school in theoretical chemistry is again being organized at Oxford during September 14–28. As in each of the previous years, the School is being directed by Prof. C. A. Coulson. Other courses are to be given by Prof. D. P. Craig, Dr. S. L. Altmann, Dr. J. W. Linnett and Dr. J. T. Lewis. Inquiries should be made in the first instance to the Delegacy for Extra-Mural Studies, Rewley House, Wellington Square, Oxford, from which a descriptive brochure can be obtained. Accommodation (at St. Antony's College) is limited. The closing date for applications is May 15.

A symposium on "Humane Technique in the Laboratory", organized by the Universities Federation for Animal Welfare, will be held in the Harkness Hall, Birkbeck College, Malet Street, London, on May 8, under the chairmanship of Prof. P. B. Medawar. The symposium will be introduced by Major C. W. Hume, secretary-general of the Federation; papers will be read by Dr. W. Lane-Petter, Dr. Phyllis Croft, Dr. W. M. S. Russell, Mr. G. Sykes, Dr. F. K. Sanders, Dr. W. Grey Walter and Dr. M. R. A. Chance. These will be published later in the year in Vol. 6 of the Laboratory Animals Bureau Collected Papers. Admission to the symposium is without charge.

The Istituto Sperimentale Italiano 'L. Spallanzani', which is affiliated to the University of Milan and this year celebrates the twentieth anniversary of its foundation, is organizing an international symposium on "Zootechnical and Health Aspects of Artificial Insemination", to be held in the agricultural and technical quarter of the thirty-fifth International Samples Fair in Milan, during April 23–24. The symposium will be presided over by the Director of the 'L. Spallanzani' Institute, Prof. T. Bonadonna, of the University of Milan, to whom all inquiries should be addressed.

The Scientific Film Association, on behalf of the International Scientific Film Association, is organizing a conference to be held at the French Institute, South Kensington, London, S.W.7, during April 4–6, which will be attended by sponsors of films, scientists and television producers from Britain and overseas. The main question to be considered is how films and television can do more to introduce and interpret science to the man in the street. The conference will be opened by Prof. P. M. S. Blackett, president of the British Association. Inquiries should be addressed to the Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2.

INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE

REPORT FOR 1955–56

THE annual report for 1955–56 of the Indian Association for the Cultivation of Science* pays warm tribute to Prof. M. Saha, its director, who died on February 16, 1956, and gives some details of the revised Five-Year Plan of the Association for 1956–61. These include the creation of a new Department of Magnetism, establishment of a research training centre in analytical chemistry and a training section in high polymer technology. In the Department of General Physics, X-rays and Magnetism, work on thermal diffusion and inter-diffusion of gases continued and the design of the thermal diffusion column (of the concentric metallic tube type) was completed. An apparatus for measuring diffusion coefficients over a wide range of temperatures, a low-temperature bath operating down to liquid air temperatures and a differential conductivity analyser have also been designed and constructed. Two methods have been developed for determining the potential parameters for unlike molecules on the modified Buckingham exponential-six model from experimental data on thermal diffusion. The thermal conductivities of gaseous neon, argon and krypton and of their binary and ternary mixtures have been determined and work continued on the application of the methods of Hesse, Stoswick and Lipson to determine crystal classes, *hkl* indices and space groups. The radial distribution of carbon has been calculated from the X-ray diffraction of amorphous carbonized organic substances at 500–1,000° C. Measurements of the magnetic anisotropies of single crystals of hydrated salts of Fe^{++}, Co^{++}, Ni^{++} and Cu^{++} at moderately high and at low temperatures indicated that the behaviour of all salts having the same paramagnetic ion is roughly the same, and attempts are being made to explain the anomalies. A systematic study was commenced of the magnetic anisotropies of single crystals of Tutton salts of Cu^{++} ions differently diluted with zinc, etc., at room and at low temperatures, and X-ray studies of the inherent distortions in the lattice of single crystals of graphite continued.

In the Department of Optics studies have been made of the Raman spectra of *m*-chlorotoluene, *m*-bromotoluene and the three cresols in the solid state at different temperatures and of those of bromobenzene, anisole and methyl and ethyl benzoates in the liquid and solid states. Observations of the Raman spectra of frozen solutions of carbon disulphide in methylcyclohexane at − 180° C. suggest that the lines 70 and 81 $cm.^{-1}$ are due to vibrations in dimers. Studies of the fluorescence of *p*-chlorotoluene at − 180° C. and in frozen solutions led to the conclusion that the fluorescence bands are due to association between the chlorine atom of one molecule and the hydrogen atom of a neighbouring molecule. Studies of the absorption of 3·18 cm. microwaves in *o*-bromophenol, 2 : 4 : 6-trichlorophenol, *o*-methoxyphenol, *p*-cresol and diphenyl ether in the liquid state showed maximum absorption at certain temperatures with *o*-methoxyphenol and *p*-cresol and the radius of the rotor calculated from Debye's theory was that of the hydroxyl group rotating about an axis in the molecule.

In the Department of Theoretical Physics an attempt was made to determine the relative importance of spin and relativity on the decrease of the Klein–Nishina cross-section in the Compton scattering of light with increasing photon energy. Other work was concerned with polarization effects in proton–proton scattering and with magnetic moments of the nucleons. The Department of Physical Chemistry is studying the mechanism of the formation of colour in the polymerization of methyl *iso*propenyl ketone. A micro-colorimeter has been constructed and standardized, and is being used to study the thermodynamic properties of high polymer solutions. Other studies were concerned with the effect of end groups on the osmotic behaviour of polymethyl acrylate, the efficiency of azo-*bis* nitriles as initiators in vinyl polymerization, the styrenation of shellac in alcoholic media, the kinetics of decomposition of lauroyl peroxide and the applicability of non-aqueous acid-base titration for analysis of organic compounds.

The Department of Organic Chemistry has obtained important correlations between the peculiar mechanical properties of the fibres of *Bombax malabaricium* and the structure of the fibre. A tentative constitution has been deduced for a crystalline lactone isolated from cactus roots of Kashmir origin, while investigations on polynuclear compounds and fused alicyclic systems are being actively pursued. The Department of Inorganic Chemistry continued to be concerned mainly with the study of co-ordination complexes and their application in analytical chemistry. The diphenyl, dimethyl, diethyl and dibenzyl derivatives of rubeanic acid have been used in the colorimetric determination of copper, cobalt, nickel and palladium, and a number of bi-positive silver complexes with pyridine carboxylic acids have been prepared which are fairly stable and highly coloured and have a magnetic moment of nearly 1·74μ, while benziminazole has been used for the gravimetric determination of silver and 3- and 5-oximino-methylsalicylic acids for the estimation of copper and its separation from other metals.

* Indian Association for the Cultivation of Science. Annual Report for 1955–56. Pp. 81. (Jadavpur, Calcutta: Indian Association for the Cultivation of Science, 1956.)

UNITED STATES FEDERAL RESEARCH AND DEVELOPMENT BUDGETS FOR 1955, 1956 AND 1957

IN the fifth of its reports, "Federal Funds for Science"*, the National Science Foundation analyses the U.S. Federal research and development budget for the fiscal years 1955, 1956 and 1957, including for the first time, besides data on several small agencies not previously reported, the pay and allowances of military personnel in research and

* National Science Foundation. Federal Funds for Science. 5 : The Federal Research and Development Budget, Fiscal Years 1955, 1956, and 1957. Pp. ii+47. (Washington, D.C.: Government Printing Office, 1957.) 35 cents.

development establishments. The analyses are presented after the pattern of the three previous reports, but data are also given on the allocation of Federal funds for research and development in the Government's own laboratories, and in profit- and non-profit-making organizations, including educational institutions. Expenditure on the collection of general purpose statistics is now excluded.

The total U.S. Federal Government expenditure on research and development is estimated at about 2,300 million, 2,400 million and 2,700 million dollars in 1955, 1956 and 1957, respectively. These figures should be increased to 2,900, 3,100 and 3,400 million dollars, respectively, if expenditure from procurement and production appropriations of the Department of Defense for analogous work in the field of engineering is taken into account. Excluding such expenditure but including pay and allowances for military personnel, these figures would be 2,300, 2,500 and 2,900 million dollars. About 85–90 per cent of the total is for research and development, the balance being for the expansion of research and development plant.

If the Department of Defense is considered a single agency, these funds were administered by twenty-five agencies of the executive branch in 1955 and by twenty-four agencies in 1956 and 1957, agencies engaged in collecting data, training scientists, etc., being no longer included. Individual agencies administer funds ranging from less than 50,000 dollars to about 2,000,000,000 dollars, but 99 per cent of the expenditure in each of the three years is accounted for by eight agencies, among which the Department of Defense (1,936 million dollars) and the Atomic Energy Commission (529 million dollars) rank first and second, respectively, while the budget of the Department of Health, Education and Welfare (110 million dollars) now exceeds that of the Department of Agriculture (103 million dollars). The National Advisory Committee for Aeronautics (80 million dollars) and the Department of the Interior (44 million dollars) come next, while the National Science Foundation, the expenditure of which has risen from 10 million dollars in 1955 to 21 million dollars in 1956 and 43 million dollars in 1957, has now passed the Department of Commerce (24 million dollars), largely due to the funds it administers for the International Geophysical Year, though apart from this it would still retain its place among the eight principal agencies financing research and development.

In scientific fields, the physical sciences (including engineering sciences) continued to claim the major share, the proportion during 1955–57 being 87 per cent compared with 11 per cent for the biological sciences and 2 per cent for the social sciences. Commitments for the physical sciences are estimated to have increased by more than 17 per cent in 1956 and a further increase of 7 per cent is expected in 1957; about 95 per cent of funds for use in this field are administered by the Department of Defense, the Atomic Energy Commission and the National Advisory Committee for Aeronautics. Funds for the biological sciences come mainly from the Departments of Health, Education and Welfare; Defense; the Interior; and the Atomic Energy Commission, Veterans Administration and the National Science Foundation; they increased about 11 per cent in 1956 and are expected to increase about 18 per cent in 1957, when expenditure is estimated as 143 million dollars on medical sciences, 72 million on biological sciences and 54 million dollars on agricultural sciences. Funds for the social sciences, about 40 per cent of which come from the Department of Agriculture, increased by 27 per cent in 1956 and a 20 per cent increase is envisaged in 1957.

Of the total expenditure in 1955, 130 million dollars was on basic research, of which 42·3 million was on biological sciences, 85·7 million on physical sciences and 2·1 million dollars on social sciences; in 1956 the corresponding figures are estimated at 162 million, 50·5 million, 108·7 million and 2·9 million dollars, and in 1957, 215 million, 71·8 million, 138·8 million and 4·5 million dollars, respectively. Expenditure on applied research and development in 1955 was 1,915 million dollars, of which 164 million was on biological sciences, 1,570·1 million on physical sciences, 23·3 million on social sciences and 157·2 million dollars on pay and allowances of military personnel. For 1956, the corresponding figures are estimated at 2,208 million, 178·2 million, 1,835·6 million, 29·3 million and 164·6 million dollars, and for 1957 at 2,336 million, 197·3 million, 1,935·8 million, 34·2 million and 168·9 million dollars, respectively.

In 1956, 47 per cent of the total, or 1,110 million dollars, including pay and allowances, was spent within the Federal Government's own institutions, 38 per cent, or 899 million dollars, in profit-making organizations, and 13 per cent, or 304 million dollars, on educational institutions. About 15 per cent of the total was expended in research centres, of which roughly 8 per cent were connected with profit-making organizations, 6 per cent with educational institutions and 1 per cent with non-profit-making organizations.

The report includes graphs of the figures for expenditure on research and development since 1940. Although there is a general tendency for expenditure on research and development to increase, this trend would probably be substantially reduced if the data were expressed in terms of constant prices.

SURGICAL TECHNIQUES IN THE STUDY OF FLORAL MORPHOGENESIS

F. CUSICK has described floral ontogenesis in *Primula bulleyana* and has shown that the application of surgical techniques may contribute to an understanding of some aspects of the observed developments (*Trans. Roy. Soc. Edin.*, 63, 153; 1956).

The flower of *Primula bulleyana*, in its early ontogeny, passes through presepal, primordial-sepal, primordial-stamen and ovarial stages. Petals first appear at either the end of the primordial-stamen stage or the beginning of the ovarial stage. The relatively long presepal stage is conveniently divided into early, mid and late periods. If a flower primordium in the early-presepal stage is bisected with a median incision, the tissue along (and on each side of) the wound typically produces the full sequence of floral parts—sepals, stamens and petals, and an ovary. Bisections of older primordia indicate that the ability to form sepals in this position is lost during the mid-presepal stage; at about the late-presepal stage, the ability to form stamens and petals along the wound is also lost. Paired ovaries (a complete ovary on each side of the cut) still develop

after most primordial-sepal stage bisections and after a minority of primordial-stamen stage bisections.

In primordia bisected during the ovarial stage, the ovary wall usually develops as two arcs, separated by the wound and widely open above it. These results are interpreted as evidence in favour of the hypothesis that a developing flower passes through a succession of physiological states that permit and regulate the formation of each kind of organ in turn. The sites of new organs are defined by existing ones, or by the creation experimentally of new areas marginal to a new morphogenetic centre. But the nature of the organs formed is more a response to the morphogenetic state of the primordium as a whole.

PHYSICAL MEASUREMENT OF CONE PIGMENT IN THE LIVING HUMAN EYE

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IT has long been recognized that twilight vision is mediated by the rods of the retina, and that the first step in the utilization of light is its absorption by the visual pigment rhodopsin (visual purple). The ensuing photolysis results in bleaching, and upon measurements of this colour-change a great body of knowledge has been built.

Daylight vision with colour discrimination is mediated by the cones, and it is generally believed that these contain visual pigments analogous to rhodopsin. One such pigment, 'iodopsin', has in fact been extracted by Wald[1] from the predominantly cone eyes of the chick. Its sensitivity is maximal in the yellow-green and it regenerates much faster than does rhodopsin. These are properties likely to be possessed by human cone pigments, but since cones (in the chick) appear to contain extremely little extractable iodopsin, the chance of obtaining detectable quantities from mammalian eyes (where, in general, rods predominate) is not good, and so far attempts have proved unsuccessful. It is therefore satisfactory that an alternative approach seems available, and that physical measurements made upon the normal human eye may give information about the cone pigments of the fovea.

Campbell and I[2] were able to develop a technique of ophthalmoscopic densitometry by means of which we could measure the change in rhodopsin density which occurred in any small region of the retina as a result of change in the light falling there. A modification of the apparatus has permitted the former conclusions to be confirmed and amplified[3], and the present account summarizes what seems reliable in an extension to the analysis of the cone pigments in the human eye.

In essence the method is that of ref. 3. Yellow light too weak to bleach the pigments appreciably was passed through a photometric wedge and shone into the eye through one half of the dilated pupil and brought to a focus upon the fovea in a 2·7° circle centrally fixated. The small fraction of this light which was reflected back from behind the retina and left through the other half of the pupil was caught upon a 45° mirror and reflected sideways into a red-sensitive E.M.I. photomultiplier tube. Since this light had passed twice through the retina it must have suffered absorption by the yellow-absorbing cone pigments there. If, now, these were bleached away by exposure to a strong light the signal received by the photocell would be stronger, and in order to reduce it to its former strength the wedge would have to be displaced to a denser position. The increase in wedge density will clearly be equal to the decrease in the pigment double-density (= density for a double passage).

In practice, a great many precautions must be taken if the change in photocell output is to measure simply the change in the density of the visual pigment. These have already been described[3], and the present account simply gives in outline the principle upon which it is possible to deduce the change in the density of cone pigments from an analysis of light received from the eye.

(*a*) *The rate of regeneration.* The subject fixated continuously for about 10 min. but especially at the moments when the wedge was being set to return the photocell output to its initial value. In Fig. 1 the wedge settings are expressed as the density of wedge interposed (measured downwards) which is the same as the double-density of the photolabile pigment measured upwards from an arbitrary zero. Initially the eye is dark-adapted (though exposure to the moderate artificial lighting of the dark room constitutes 'dark adaptation' for cone pigments; so rapid is their regeneration).

Then a very bright light was shone upon the fovea for 30 sec. and immediately afterwards wedge settings were taken, at first in quick succession, later at longer intervals. As is seen from Fig. 1, there is a sudden change of some 0·15 in density upon bleaching. Regeneration follows a curve of exponential type, which in 90 sec. has half returned and in 5 or 6 min. has reached the initial value.

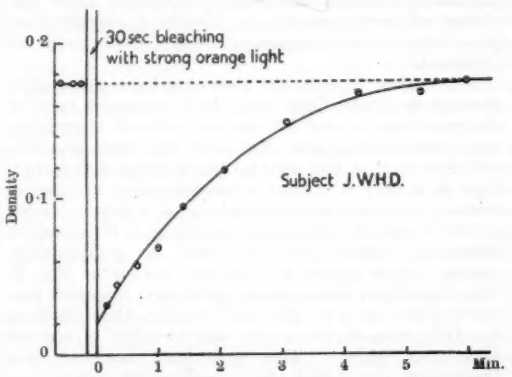

Fig. 1. Ordinates, double-density of foveal visual pigments. Initial values, after dark adaptation. The gap represents 30 sec. bleaching with strong orange light (Ilford filter 203). Density measurements were then made during dark adaptation at times shown. Recovery is complete in 6 min.

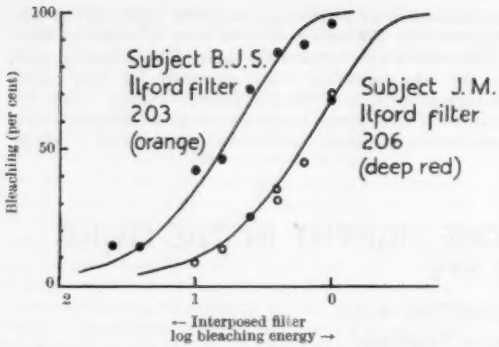

Fig. 2. Ordinates, percentage bleaching produced by light flashes of various intensities, as given by abscissæ on a logarithmic scale. The curves show the theoretical relation to be expected from any visual pigment

This is a very regular phenomenon, and easy to obtain. Rhodopsin cannot be the pigment involved, for the fovea contains no rods, neither is rhodopsin bleachable by the orange light used nor measurable by the yellow; and it take half an hour to regenerate[3].

(*b*) *The rate of bleaching.* The course of bleaching cannot be measured in the same way, for when the bleaching light is strong the process goes too fast, and when weak, bleaching is confounded by concurrent regeneration. The method adopted was to bleach for exactly 10 sec. and then immediately to make measurements during dark regeneration. From these the total density change after exactly 10 sec. in the dark could be read off by interpolation. The bleaching light could be of various wave-lengths and various intensities. By keeping the *time course* of these operations always identical, the complications of regeneration are nearly removed. For at the moment when the density was measured the amount of regeneration was nearly proportional to the amount of bleaching, and hence the results approximate to those expected in the absence of regeneration (at a slightly reduced density scale).

Fig. 2 shows the percentage bleaching plotted as a function of the logarithm of the bleaching energy. Abscissæ show the density of neutral filters interposed in the path of the fixed bleaching light (scale ascending towards the left); ordinates show the change of wedge setting on bleaching expressed as percentage of the maximum change which could be obtained.

For subject B. J. S. the bleaching light was passed through an Ilford filter 203, which transmits most of the spectrum beyond 570 mμ and cuts off everything of shorter wave-length. For J. M. the filter was 206, which cuts off at 630 mμ and hence appears deep red. Now it is easy to derive a mathematical expression relating the percentage bleaching of a dilute photosensitive pigment with the logarithm of the incident bleaching energy provided that no regeneration occurs. It is shown by the two curves of Fig. 2. The expression has a single arbitrary constant permitting the curve to slide horizontally, thus allowing for differences in the colour and strength of various bleaching lights. The agreement between this theoretical curve and the experimental points supports the view that a visual pigment is being measured.

(*c*) *Spectral photosensitivity.* The 'arbitrary' constant above is, in fact, completely determined if we know the energy and composition of the bleaching light and the spectral photosensitivity of the foveal pigment. We may therefore estimate the photosensitivity by evaluating the constant from Fig. 2 and measuring the bleaching energy photometrically.

The bleaching light was always a wide spectral band. This (reduced in intensity by neutral filters) was matched both for colour and brightness against a narrow spectral band, and it is assumed that lights which look alike bleach visual pigments equally. The results are thus interpreted as though the bleaching light was in fact that monochrome.

In principle, then, the experiment was to obtain upon the subject a series of bleaching curves as in Fig. 2, using bleaching lights of various colours. Since each *point* upon the curve represents an experiment rather like Fig. 1, the procedure had to be shortened, so instead of plotting the whole of the Fig. 2 curves, just a couple of points were obtained near the 50 per cent level which adequately determined the lateral shift of the theoretical curve.

Fig. 3 (circles) shows the logarithm of the spectral photosensitivity obtained by this method, plotted against that wave-length which matches the colour of the bleaching light. The red and green logarithmic sensitivity curves of Stiles[4] are also shown, derived from psychophysical measurements of just perceptible increment thresholds.

The absolute value of the photosensitivity (that is, 1/number of quanta cm.$^{-2}$ required to reduce the pigment to 1/*e* of its initial density) was calculated upon the usual assumption that half the bleaching light was lost in the eye media[5]. For optimum colour the value is 4×10^{-16} cm.^{2}. This is 4·5 times as great as the sensitivity of rhodopsin in solution[6] but only a quarter the figure which Brindley[7] has deduced from changes in colour matches after viewing very bright lights.

Conclusions. Despite obvious limitations in technique, results have been obtained which permit some comparison with theory and with the psycho-physical measurements of colour vision. Relation (*b*) points to changes in a *visual pigment* and it is clear from (*a*) that this cannot be rhodopsin. Wald's[1] iodopsin would fit nicely. However, there is clear evidence[8] that at

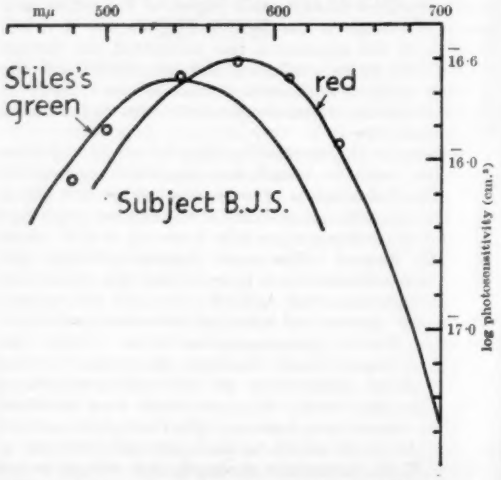

Fig. 3. Circles, logarithm of the spectral photosensitivity of foveal pigments (cm.$^{-2}$). Curves, Stiles's red and green sensitivity curves determined by increment thresholds

least two photo-labile pigments are present in the fovea, though I have not yet succeeded in separating them satisfactorily. All the work described here was designed to give prominence to the red-sensitive component, and the results of bleaching with red lights are probably confined to it. These points (Fig. 3) lie upon Stiles's curve for 'red' sensitivity. When, however, green or blue lights were used for bleaching, the green-sensitive pigment was probably more affected and may have contributed conspicuously to the photosensitivity measured. Certainly these points lie closer to Stiles's 'green' sensitivity.

The fact that cone photosensitivity is several times that of rhodopsin suggests that light is more concentrated in cones than in rods (see Tansley and Johnson's[9] beautiful photograph of light in snake's cones). Great economy would then result if the visual pigment were also concentrated at this focus.

The actual density in the cones must be greater than my wedge differences, and this is already some 0·15 double density—about the same as rhodopsin on average. This large density can be reconciled with the negligible quantity extractable if a small amount were very concentrated at the effective focus of the cone. Such an arrangement would also explain the high photosensitivity and the Stiles–Crawford directional effect, and it would account for the success of the present type of measurement. For the photocell 'views' the visual pigment through the magnifying system of the cone, and, just as a lamp filament at focus fills the whole (Maxwellian) lens with light, so may most of the cones' inner segments be optically filled with the great density of but a particle of pigment if that lies at the focal point.

I wish to thank the Medical Research Council for a grant, Clive Hood for his ready help and resource, and the many students who volunteered as subjects for coming so often and fixating so steadfastly.

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MECHANISM OF RETICULO-ENDOTHELIAL STORAGE

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THE mechanism of reticulo-endothelial storage by which microheterogenic and colloidal living and non-living particles circulating in the blood stream linked to protein are accumulated at the site of stimulation has not yet been sufficiently elucidated. The analogy of storage to phagocytosis is still open to debate, and it is not known how the substance to be stored can enter the cell adsorbed to protein or how it is transferred from the cell into the extravascular space. The significance of the linkage to protein is also unknown.

Gróf[1], one of our associates, observed several years ago that procaine and its derivatives prevented reticulo-endothelial storage in the skin of rabbits and rats. He showed that 1–2 hr. following the intravenous injection of trypan blue, which is known to be not readily transmitted by semi-permeable membranes, the skin of the animal became discoloured by the dye diffusing into the extracellular space; but no diffuse blue colour appeared at the site of procaine injection. A purely central nervous effect cannot be held responsible for the above phenomenon, because it has been shown experimentally that the skin of the perfused isolated limb exhibited storage under the influence of a wide variety of stimuli when the perfusion fluid contained protein and an electronegative dye.

As procaine inhibits reticulo-endothelial storage and synaptic transfer alike, it has been suggested that the forces controlling reticulo-endothelial storage may be similar to, or eventually identical with, those responsible for synaptic conduction. This view is further supported by the demonstration that all agents which are known to interrupt nervous conduction also inhibit storage. According to Fleckenstein[2], such inhibitors are potassium and rubidium ions, citrates, oxalates and some cellular respiration blocking agents.

In the present experiments more than a hundred albino rats were used. The skin of the back was epilated by means of barium sulphide paste at least 48 hr. prior to the experiment. Intradermal injections of procaine, 0·76 per cent calcium chloride, 0·76 per cent potassium chloride, isotonic sodium citrate, sodium fluoride and oxalate were then given at separate sites, and each animal next received 2 ml. of 1 per cent trypan blue dissolved in distilled water intravenously. The untreated sites served as controls.

It was found that inhibition was complete at the sites of injection of procaine, calcium chloride and potassium chloride, and incomplete at the injection sites of isotonic sodium citrate, sodium fluoride and oxalate.

It is well known that reticulo-endothelial storage is inhibited by stoppage of the blood flow. However, in isotonic concentration, none of the blocking agents of synaptic junctions used caused such vascular changes; and after intradermal injection of these compounds we have never observed by capillaroscopy *in vivo* a stasis in the small blood vessels of the skin, or any appreciable vascular changes in biopsy specimens.

From these experiments we suggest that the conditions for reticulo-endothelial storage are similar to or identical with those for synaptic conduction.

Storage in vitro. To study storage experimentally, a Michaelis cell was prepared, consisting of a glass ring sealed with rat or calf peritoneum. The cell was

filled with heparinized rat or human plasma or serum, and its external surface was submerged in Tyrode's solution containing 0·1–0·2 per cent blood serum. The whole model was maintained in an incubator at 37° C. In the model the capillary wall was represented by the animal peritoneum and the circulating blood by the fluid in the cell. In this arrangement the external aspect of the rat peritoneum was electropositive and did not permit the passage of detectable amounts of albumin or trypan blue linked to albumin during the first 30 min. of the experiment.

On stimulating the external surface of the peritoneum by mild burning or painting with 0·1 per cent histamine, permeability increased, and in 30–40 min. appreciable quantities of albumin, or of trypan blue attached to albumin, passed into the fluid outside the cell, representing the extracellular space. In the presence of trypan blue a blue spot visible to the naked eye developed in the stimulated areas of the peritoneum. This phenomenon is essentially the same as that described by Schürer[3] and Ebbecke[4], namely, an accumulation of dye at the stimulated areas. Microscopically, the stored dye was found in sol form chiefly in the extracellular spaces.

As our investigations showed the mechanism of storage to be similar to that of synaptic conduction, it was assumed that in storage also electric phenomena would take place. It is known that in the Donnan model, in which the semipermeable membrane inhibits or slows down the transfer of albuminate ion and in which the concentration of both cations and anions is different on the two sides, a potential difference, estimated at about 20 mV., will develop at the normal *p*H relations prevailing in blood. In our cell we have measured approximately 30 mV., by using the string-type galvanometer, and non-polarizing copper–copper sulphate, or mercury and calomel electrodes.

As already mentioned, the permeability of the peritoneum increased after painting with histamine or burning. Albumin, as well as trypan blue attached to albumin, passed in such cases into the external fluid space representing the extracellular space and reached significant concentrations therein. At the same time the electropositivity of the membrane increased. Our instrument indicated an increase in the electric potency of the cell.

From these results it appears that storage is the result of an increase in permeability and also in the electropositivity of the cell membrane, induced by exogenous or endogenous histamine action, which produces increased ion concentration changes similar to the injury potential. In such cases the microheterogenic or colloidal particles, which are linked to the blood proteins and are electronegative, migrate as in electrophoresis towards the anode in the electric field and pass through the membrane into the extracellular space.

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RECOVERY OF LETHALLY IRRADIATED MICE BY TREATMENT WITH BONE MARROW CELLS MAINTAINED *IN VITRO*

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It has been demonstrated by Lorenz and his associates that death from acute radiation can be prevented by treating irradiated animals with normal bone marrow cells[1,2]. Lorenz's group (C. C. Congdon, personal communication) made several unsuccessful preliminary attempts to prove that tissue-cultured, blood-forming tissues would keep lethally irradiated animals alive.

The experiments reported here were undertaken with the following objectives: (*a*) retention of effective bone marrow cells in tissue culture; (*b*) identification of the cell type or types responsible for the recovery of lethally irradiated animals; and (*c*) multiplication of such cells. The present communication is concerned with (*a*), and shows that bone marrow cells can be maintained *in vitro* for two weeks and still retain their ability to keep lethally irradiated mice alive. Miller has reported that injections of embryonic liver after four days in tissue culture prevents death from acute radiation[3].

The vaccine vial-suspension method of Osgood and Brownlee[4] with the modifications to be described was used. Bone marrow cells of twelve- to fourteen-week-old $C_3H \times 101F_1$ mice were obtained by flushing out the marrow from femurs with a needle and syringe containing the culture medium. Clumps were broken up in the suspension by the gentle agitation of several pipettings. Each femur yielded 10–12 million nucleated cells. An aliquot of the cell suspension was stained with a methylene blue – acetic acid mixture, and the stained nuclei were counted in a hæmocytometer. 15 ml. of a cell suspension, containing 6,000–8,000 nucleated cells per ml., was added to a 25-ml. vaccine vial. Two vaccine-vial cultures were usually used for each experiment. After addition of the cell suspensions, the vials were capped with rubber vaccine-vial stoppers and incubated at either 37° or 25° C. The cultures were allowed to remain undisturbed except for changing the medium. Changes of medium were made by removal of 6–10 ml. of the cell-free fluid above the settled cells and the addition of an equal amount of fresh medium. At termination of the culture, a portion of the cell-free fluid was removed and the remaining fluid used to suspend the cells. In the cultures incubated at 37° C., some cells were attached to the glass surface after removal of the cell suspension. These were resuspended by treatment with 0·25 per cent trypsin in Hanks's salt solution as described by Puck[5]. The resuspended cells were combined with the initial cell suspension, and a nucleated cell count was made from an aliquot of the final suspension. The compositions of the several media used for tissue culture are given in Table 1.

Table 1. Composition of the Culture Media

Medium*	Gey's salts	Serum content (per cent)	Chick embryo extract (per cent)
C	65	30 (horse)	5
E	40	60 ,,	0
I	40	60 (mouse)	0

* All media contained 50 units each of streptomycin and mycostatin plus 80 units of penicillin/ml.
As given by Gey and Gey (*Amer. J. Cancer*, **27**, 45; 1936) except that 0·25 gm./l. of sodium bicarbonate was used.

Male and female $C_3H \times 101F_1$ mice twelve to fourteen weeks old were used for testing the ability of the tissue-cultured bone marrow cells to bring about recovery after lethal exposure. The mice were given 900 r. of X-rays in a partitioned rotary plastic drum; radiation factors were 250 kVp., 30 m.amp., 3 mm. of aluminium added filtration, 80 cm. distance from X-ray target, dose-rate in air approximately 95 r./min. Within one to two hours after irradiation, the experimental mice were injected intravenously with 0·25–1·0 ml. of a cell suspension.

The results presented in Table 2 show that, under favourable conditions, the effectiveness of cultured bone marrow cells in causing recovery of lethally irradiated mice was preserved for fourteen days. At an incubation temperature of 37° C., the most favourable conditions included a medium having a high serum content (medium *E*) plus a feeding schedule of 24 hr. The use of a medium consisting of a lower serum content to which chick embryo extract was added (medium *C*) resulted in the earlier loss of effective cells (Table 2). Isologous serum (medium *I*) proved to be less satisfactory than the heterologous horse serum.

The maintenance period of effective cultures was increased by incubation at 25° C. At this temperature, the cells of a seven-day culture in medium *C* brought about a 95 per cent survival when injected into lethally irradiated mice as compared to 27 per cent when the cells were obtained from a seven-day culture in the same medium but incubated at 37° C. (Table 2).

Table 2. Recovery of Lethally Irradiated Mice by Tissue-Cultured Bone Marrow Cells

Material injected	No. of nucleated cells injected/animal (millions)	Thirty-day survival	Percentage survival
(*A*) Cultures incubated at 37° C. in:			
Medium *C*			
4-day culture	0·8–3·2	17/18	92
6-day ,,	1·6–3·5	6/25	24
7-day ,,	3·7–7·5	4/15	27
9-day ,,	1·4	0/9	0
Medium *E*			
7-day culture	1·4–2·8	12/13	92
9-day ,,	0·75–1·3	7/14	50
10-day ,,	0·7	4/4	100
11-day ,,	0·14–0·5	0/2	0
11-day ,,	1·9	2/4	50
Medium *I*			
7-day culture	20·0 (?)*	0/7	0
(*B*) Cultures incubated at 25° C. in:			
Medium *C*			
7-day culture	4·3–8·7	19/20	95
Medium *E*			
11-day culture	0·9–1·8	11/11	100
12-day ,,	1·3–2·7	6/10	60
13-day ,,	1·25	6/8	75
14-day ,,	0·06	7/12	58
(*C*) Controls			
No treatment	—	6/334	2
Medium *C* only	—	0/8	0
Medium *E* only	—	0/11	0
Cell-free supernatant from 2-day culture: Medium *C*	—	0/4	0

* Observations on stained smears showed much cell debris; only normoblasts were recognizable.

Injection of either fresh medium or the cell-free supernatant from a two-day culture did not increase the number of survivors among the lethally irradiated mice (Table 2). These results are based on a thirty-day survival period. Very few additional deaths have occurred in the surviving mice observed for as long as five months after treatment.

The number of nucleated bone marrow cells required to bring about recovery in exposed mammals has occupied the attention of a number of investigators[2,6]. In these experiments, a question may be raised as to the number of viable cells actually injected. Stained smears showed many degenerate forms as well as nuclear debris. In the counting procedure used, it was sometimes difficult to distinguish between intact and degenerate nuclei. Where doubt existed, the forms were included in the total nucleated cell counts recorded in Table 2; thus these counts are probably an over-estimate of the true number of intact viable cells present. For further information on this matter, Schrek's technique[7], which is based on eosin staining of dead cells, was used in several experiments. In fresh marrow preparations, less than 2 per cent of all cells present stained pink. In the eleven-day culture promoting 100 per cent recovery in irradiated mice (Table 2), 30 per cent of the cells showed uptake of the dye, indicating the loss of selective permeability, and were presumed to be dead cells.

Experiments in progress may give further information on the tissue-cultured cell type or types responsible for recovery of treated lethally irradiated mice.

Mice exposed to lethal doses of X-rays showed 100 per cent survival if treated with bone marrow cells maintained *in vitro* for eleven days. Twelve- and fourteen-day cultures were partially effective. The conditions most suitable for maintenance of such cultures included a culture medium of high serum (heterologous) content, replenishment of the medium every 24 hr., and incubation of cultures at 25° C.

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Note added in proof. Since this manuscript was submitted for publication, the maintenance time of effective bone marrow cell suspensions has been extended to 21 days by incubation of bone marrow cells in medium 199 plus horse serum at 25° C.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Spontaneous Ignition of Gaseous Hydrogen Azide

Hydrogen azide is an extremely unstable and endothermic compound, and even in the absence of oxygen it may detonate violently. Nitrogen, hydrogen and ammonia are its decomposition products, and stoichiometrically decomposition must lie between the extremes of equations (1) and (2). Experimentally, it is found that the slow thermal decomposition of gaseous hydrogen azide is heterogeneous[1] and follows equation (2), yielding mainly ammonia, while the rapid, explosive decomposition initiated by sparking[2] follows equation (1), yielding no ammonia:

	Enthalpy increase ΔH (kcal. mole^{-1})	Pressure increase ΔP (per cent)
HN_3 (1) $1/2H_2 + 3/2N_2$	−71	100
HN_3 (2) $1/3NH_3 + 4/3N_2$	−75	66·7

The spontaneous ignition of ethyl azide has been examined and interpreted[3] in terms of thermal explosion theory applied to the slow reaction[4]. Accordingly, we have now examined in outline the spontaneous ignition of hydrogen azide. The apparatus used has been described elsewhere[5].

Explosive ignition. Critical limits of pressure and temperature exist above which admission of hydrogen azide to the reaction vessel is succeeded by violent explosion. Induction periods are brief—about one-fifth of a second—and the white flash of spontaneous ignition often travels back into the remainder of the apparatus, igniting the cold vapour there. The final increase of pressure is 100 per cent. This is in accord with equation (1) and in agreement with the results of work[2] on the spark ignition of hydrogen azide. Fig. 1 shows the relation between temperature and pressure required for ignition.

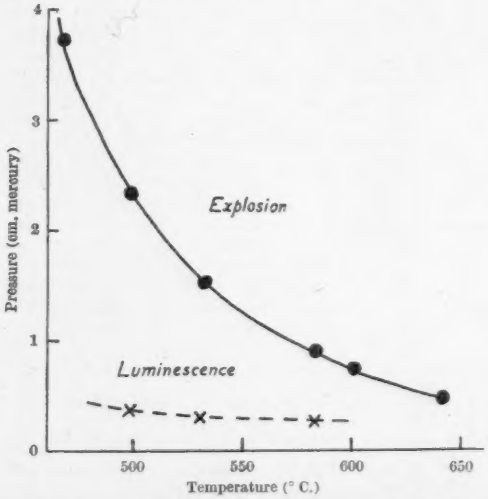

Fig. 1. Spontaneous ignition of gaseous hydrogen azide. Critical pressure limits for explosive ignition and for luminescent decomposition as functions of temperature. Cylindrical quartz vessel; ratio surface/volume, 0·6 cm.$^{-1}$

The thermal theory of spontaneous ignition, which relates the temperature-dependence of the critical pressure limit of spontaneous ignition to the activation energy E of isothermal decomposition, has been applied with success to ethyl azide. There a value of E of 39 kcal. mole^{-1} is obtained both from kinetic[4] and from ignition[3] data. The same theory applied to the results obtained here with hydrogen azide leads to the value E of 21 kcal. mole^{-1} if the overall decomposition is assumed to follow a first-order law. However, though no complete kinetic investigation of the slow, homogeneous decomposition has been reported, a preliminary study sets E between 60 and 70 kcal. mole^{-1}, and the discrepancy between the two values for E suggests that branched radical chains may play a part in the spontaneous ignition.

The decompositions of all the covalent azides that have been examined are consistent with an initial step of the type:

$$XN_3 \rightarrow XN\diagdown\!\!\diagup + N_2$$

where X is C_6H_5, RCO, etc. Striking confirmatory evidence is the production of azobenzene from phenyl azide and of F_2N_2 from FN_3. The corresponding initial step (3) for hydrogen azide yielding the di-radical, imine, is thermochemically[6] easy:

$$HN_3 \rightarrow HN + N_2 \quad \Delta H, \text{ kcal. mole}^{-1}, \sim 5 \quad (3)$$

whereas an alternative scheme based on fission of the hydrogen-azide bond (4) requires[6] almost a hundred kcal.:

$$HN_3 \rightarrow H + N_3 \quad \Delta H, \text{ kcal. mole}^{-1}, \sim 96 \quad (4)$$

and therefore could not determine the rate unless E were at least 95 kcal. mole^{-1}. Of course, the possibility of a chain reaction initiated by reaction (4) is not excluded. Such a reaction could have an overall activation energy much lower than that of the initiating step. However, strong independent evidence exists for the participation of imine radicals in the decomposition of hydrogen azide. Thus, the emission spectra of free NH or ND have been observed[7] in the explosions of hydrogen azide or deuterium azide. Also, NH has been detected[8] in the solid obtained by suddenly chilling the pyrolysis products of HN_3.

There are thus reasonable grounds for accepting equation (3) as the initial step. Subsequent reactions are thought to involve the formation of hydrogen from imine by reactions such as (5) and (6):

	ΔH kcal. mole^{-1}	
$NH + NH \rightarrow N_2 + H_2$	−154	(5)
$NH + HN_3 \rightarrow 2NH + N_3 \rightarrow 2N_2 + H_2$	−149	(6)
$NH + HN_3 \rightarrow NH_2 + N_3$	8	(7)

These steps (5) and (6) are preferred for two reasons to steps such as (7), in which amine (NH_2) radicals are formed by hydrogen abstraction. First, (5) and (6) are thermochemically[6] much more favourable than (7). Secondly, if amine radicals are important intermediates, they would be expected to yield ammonia. Now ammonia is known[9] to survive the decomposition flame of hydrogen azide unchanged, and thus its absence from the final products suggests strongly that both it and NH_2 are also absent from intermediate stages.

Luminescent decomposition. The slow reaction unaccompanied by light emission and the violent explosive ignition are not the only possible modes of decomposition of hydrogen azide. Under conditions too mild for explosion, a third mode of decomposition has been observed. This mode of inflammation is characterized by a whitish luminescence spreading from the entry to the vessel. It is preceded by an induction period of about one second. No noise accompanies the luminescence, and relatively little reaction occurs during it: the pressure increases only by some 2–5 per cent. The critical conditions for its occurrence have been measured and are shown in Fig. 1. In view of the chemical simplicity of hydrogen azide and its decomposition, especially when compared with other systems and processes giving rise to luminescence, for example, hydrocarbon oxidation, this is a remarkable result.

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Structure of Silver Iodide Dibenzoate

SIMONINI[1] found that the reaction of silver carboxylates with one equivalent of iodine gave compounds of the general formula $(R\cdot CO_2)_2AgI$: for example, $2Ph\cdot CO_2Ag + I_2 \rightarrow (Ph\cdot CO_2)_2AgI + AgI$. These compounds were further investigated by Wieland and Fischer[2], while Crawford and Simonds[3] have more recently confirmed a similar formulation for the compounds formed from silver perfluorocarboxylates. Bryce-Smith and Clarke[4] have found that homolytic phenylation and electrophilic halogenation and benzoyloxylation can occur when silver iodide dibenzoate and silver bromide dibenzoate react with certain aromatic compounds.

Prévost[5] proposed an ion-pair structure, for example:

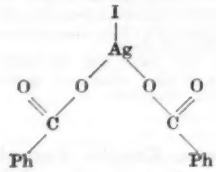
$$I^+[Ag(Ph\cdot CO_2)_2]^- \qquad (1)$$

which can explain the electrophilic halogenation reactions. It cannot account for the electrophilic benzoyloxylation reactions unless the complexes are able to react in the alternative form, for example:

$$Ph\cdot CO_2{}^+[Ag(O_2C\cdot Ph)I]^- \qquad (2)$$

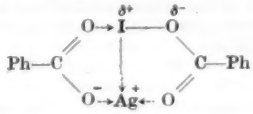
at the demand of a suitable reagent. A structure containing a formal carbonium ion is very improbable, except as an unattained limit during reaction. A serious objection to structure (1) is that it contains unco-ordinated cationic iodine. It is unlikely that a cation with six valency electrons would remain unco-ordinated in the presence of potential oxygen donors.

An alternative formulation (3) can explain the ability of the compound to function as a source of positive halogen or benzoyloxyl. However, it seems improbable that 3(or 5-)-co-ordinated trivalent silver, otherwise unknown, would be produced under mild oxidizing conditions in the presence of weak donors.



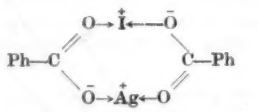
(3)

It is suggested that structure (4) for silver iodide dibenzoate meets the above objections and accords with the available evidence. The dotted lines represent



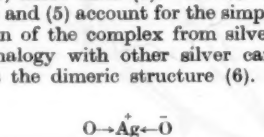
(4)

more or less weak co-ordinations, the δ-positive iodine relaying co-ordination from oxygen to silver. Structure (4) contains the elements of structures (3) and (5). The assumption of a weak silver-iodine bond,



(5)

resulting from overlap of the equatorial I^- electrons with vacant Ag^+ orbitals, enables the electrophilic halogenation and benzoyloxylation reactions to be interpreted in terms of a transition state structure resembling (3) more than (5). On the other hand, structures (4) and (5) account for the simple quantitative formation of the complex from silver benzoate, which, by analogy with other silver carboxylates[6], probably has the dimeric structure (6).



(6)

We have obtained silver iodide dibenzoate free from silver iodide by taking advantage of the ready solubility of the former in dimethylformamide. When obtained from a solution in dimethylformamide by evaporation of the solvent at 0·1 mm., silver iodide dibenzoate is an amorphous pale cream-coloured solid which decomposes below its melting point. No satisfactory X-ray powder photographs could be obtained, and attempts to prepare crystalline material were fruitless. The colourless solution in dimethylformamide slowly decomposes when kept under nitrogen at 0°. It reacts instantaneously with a solution of sodium iodide in dimethylformamide to give a precipitate of silver iodide. There is no apparent reaction with silver nitrate in this solvent.

These facts suggest the presence of Ag^+ and the absence of I^-, and are also consistent with structure (4).

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Effects of some Copper Complexes upon the Formation *in vitro* of Melanin

Cupric ions are known to accelerate the autoxidation of dihydroxyphenylalanine. It has also been reported that the action of these ions in catalysing the oxidation of the amino-acid is much enhanced by the addition of certain substances which co-ordinate with cupric ions[1].

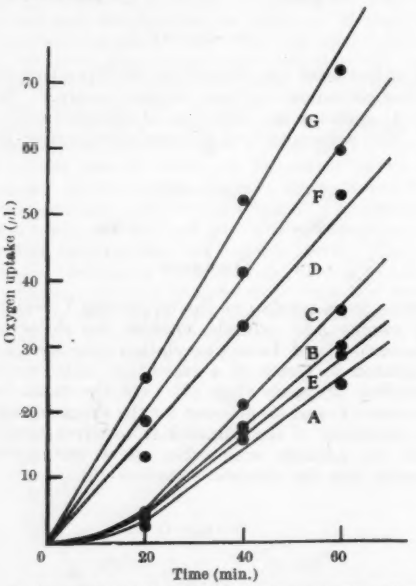

Fig. 1. Manometric determination of the accelerating effect of copper complexes upon the autoxidation of 3,4-dihydroxyphenylalanine (*p*H 7·8, 37·5° C.).
Curve *A*: 0·5 ml. of 2×10^{-2} *M* cupric sulphate, 0·5 ml. of *M*/15 phosphate buffer and 1·4 ml. of deionized water in the main chamber of the flask. Curve *B*: 1·0 ml. of deionized water in *A* replaced by 1·0 ml. of 2×10^{-2} *M* pyridine. Curve *C*: 1·0 ml. of deionized water in *A* replaced by 1·0 ml. of 2×10^{-2} *M* pyrrole. Curve *D*: 0·5 ml. of deionized water in *A* replaced by 0·5 ml. of 2×10^{-2} *M* dipyridyl. Curve *E*: 0·5 ml. of deionized water in *A* replaced by 0·5 ml. of 2×10^{-2} *M* cuproin. Curve *F*: 0·5 ml. of deionized water in *A* replaced by 0·5 ml. of 2×10^{-2} *M* *o*-phenanthroline. Curve *G*: 0·5 ml. of deionized water in *A* replaced by 0·5 ml. of 2×10^{-2} *M* neocuproin.
Other components in the main chambers were all common to *A*. Each of the side-arms of the flasks contained 0·5 ml. of 0·01 *M* 3,4-dihydroxyphenylalanine and each of their wells, 0·2 ml. of 15 per cent potassium hydroxide.
Pyrrole, dipyridyl, *o*-phenanthroline and neocuproin were dissolved in a small amount of ethyl alcohol and diluted with water. Cuproin was used as alcohol solution. These complexing agents themselves did not promote the autoxidation of dihydroxyphenylalanine in significant amount. The gas space of the manometric flask was filled with air. The contents of the side-arms were transferred into the main chambers when the flasks reached thermal equilibrium

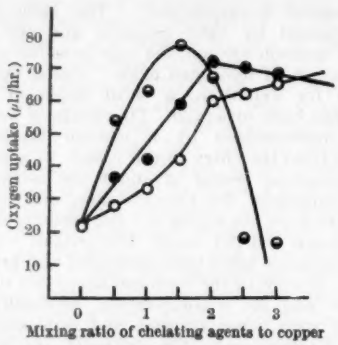

Fig. 2. Manometric determination of the catalytic activity of copper chelates as affected by the mixing ratio of chelating agents to cupric sulphate, in the autoxidation of 3,4-dihydroxyphenylalanine (*p*H 7·8 at 37·5° C.).
Each of the experimental flasks contained 0·2 ml. of 2×10^{-2} *M* cupric sulphate, a varying amount (0·1, 0·2, . . . 0·6 ml.) of 2×10^{-2} *M* chelating agent (dipyridyl, *o*-phenanthroline or neocuproin), 0·5 ml. of *M*/15 phosphate buffer and a varying amount (1·6–1·1 ml. according to the amount of the chelating agent) of deionized water. The control had 0·2 ml. of 2×10^{-2} *M* cupric sulphate, 0·5 ml. of *M*/15 phosphate buffer and 1·7 ml. of deionized water. Each of the side-arms of the flasks contained 0·5 ml. of 10^{-2} *M* dihydroxyphenylalanine, and each of the wells, 0·2 ml. of 15 per cent potassium hydroxide. Other conditions were similar to those in the experiments shown in Fig. 1. The oxygen uptake in μl. per hr. in experimental and control flasks is plotted against the concentration ratio of the chelating agent to cupric sulphate. – – – O – – –, Copper (II)-dipyridyl; – – – ● – – –, copper (II)-*o*-phenanthroline; – – – ◒ – – –, copper (II)-neocuproin

In order to get further information on the mechanism of the dihydroxyphenylalanine oxidase, we have carried out some experiments on the effects of several copper complexes upon the oxidation of dihydroxyphenylalanine. In these experiments we used, as enzyme models, some copper complexes which were formed by complexing agents such as pyridine, pyrrole, 2,2′-dipyridyl, cuproin(2,2′-diquinolyl), *o*-phenanthroline and neocuproin(2,9-dimethyl-1,10-phenanthroline). All these agents possess nitrogen atoms which may co-ordinate with metallic ions.

As shown by the curves of oxygen uptake in Fig. 1, all the above compounds co-operated with cupric ions to accelerate, more or less, the oxidation of dihydroxyphenylalanine. Cupric ions with pyridine and with pyrrole are generally known to act as oxidation catalysts, and they behaved also as such toward this amino-acid, though weak in activity (see curves *B* and *C*, Fig. 1). In each case, the metal and the organic agent were mixed in the concentration ratio of 1 : 2.

The upper three curves (*D*, *F* and *G*) represent other cases in which the mixing ratio was 1 : 1. The catalytic activity seems to increase with the structural complexity of the organic agent, in the order pyridine < dipyridyl < *o*-phenanthroline < neocuproin. This result reminds us of an interesting paper by Dr. M. Calvin[2], who enlarged the concept of evolution to include that of biocatalysts. He cited the works of Langenbeck and other authors which show parallelism between structural complexity of certain catalysts and the strength of their catalytic activity. However, copper (II)-diquinolyl had only a weak accelerating action, as curve *E* in Fig. 1 demonstrates.

The catalytic strength of the complexes varies with the mixing ratio of copper to chelating agents, as is shown in Fig. 2. Roughly speaking, the catalytic

activity of each copper chelate reaches the highest level when the mixing ratio of the metal to the organic compound is 1 : 2. In copper (II)-neocuproin, however, this optimal ratio is about 1 : 1·5; this is probably due to the steric hindrance of the methyl groups in the 2- and 9-positions. The above results, which were obtained by manometric methods, were also confirmed by the direct determination of dihydroxyphenylalanine itself by Arnow's method[3].

From these results it may be considered that all the bonds of copper in copper (II)-dipyridyl and -phenanthroline are fully co-ordinated with nitrogen atoms of the chelating agents when the catalytic activity of these complexes is at the maximum. During the course of reaction, however, the dihydroxyphenylalanine will also chelate, if temporarily, with the copper.

Among the copper complexes investigated, copper (II)-neocuproin showed the highest activity, as shown in Figs. 1 and 2. Comparing the structure of this complex with that of copper (II)-phenanthroline, it seems that the high catalytic activity has been acquired under the influence of the electron-releasing methyl groups in the 2- and 9-positions. On the other hand, copper (II)-neocuproin strongly inhibited the oxidation of the substrate if the chelating agents were present in excess, that is, if the mixing ratio exceeded 1 : 2. The competition between chelating agents and substrates for the metal would be responsible for this.

The copper seems to act as an electron carrier in this reaction, for copper (II)-chelates could be extracted with chloroform when copper (II)-neocuproin or -cuproin reacted with dihydroxyphenylalanine in an excess of chelating agents. One of the extracts was purple in colour and was found to be copper (I)-cuproin[4], having the maximal absorption band at 545 mμ; the other was orange-yellow and was identified as copper (I)-neocuproin[5], with the maximal absorption band at 457 mμ. It is likely that a reversible change of valency takes place in the copper atom under oxidation.

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A New Micromethod for the Estimation of Cellulose

The only recorded micromethod for the estimation of bacterial cellulose is that of Schramm and Hestrin[1], which requires the acetolysis of a previously purified sample and careful neutralization of the hydrolysate with sodium hydroxide prior to colorimetric estimation of the reducing power of this neutralized solution. This method is rather long—a disadvantage when several samples are to be assayed—and the neutralization step is critical. A micromethod has now been devised which halves the time taken for analysis, by eliminating acetolysis, hydrolysis and neutralization. This new method is an adaptation of that reported by Mendel, Kemp and Myers[2] for estimating blood glucose. These workers found that their method was also applicable to such polysaccharides as starch and glycogen. Although cellulose is much more difficult to hydrolyse than either of these polysaccharides, adaptation of their method has proved successful in estimating cellulose directly without initial hydrolytic treatment.

Samples of bacterial cellulose are prepared by treatment with 4 per cent (w/v) sodium hydroxide to remove cells, washed and centrifuged as described by Schramm and Hestrin[1]. Talc is added to weight the cellulose fibres in the centrifuge tubes as recommended by these workers. Each dried sample is suspended in a definite volume of water in a large test-tube to bring the concentration of cellulose within the correct range of 0–150 μgm. per ml. Three times this volume of 96 per cent (w/v) sulphuric acid is added dropwise to the tube while it is shaken. (The commercial origin of the sulphuric acid used should be one of those recommended by Mendel and his co-workers[2].) The tube is then heated for exactly 6·5 min. in a boiling water-bath, and cooled under running water. The pink solution is centrifuged to remove any suspended talc, and its optical density is measured at 520 mμ in a 'Coleman Junior' spectrophotometer. The standard curve uses glucose as a reference substance. This is a straight line between values of 0 and 150 μgm. of glucose per ml.

In a typical experiment to test the method, the cellulose formed by a static culture of *A. xylinum* was purified, air-dried, weighed and homogenized to give a uniform suspension of a concentration falling within the limits of the method. The cellulose content of a series of duplicate samples of the suspension was then estimated as described above. The results are given in Table 1.

Table 1. Recoveries of Samples of Bacterial Cellulose (in μgm.)

Weighed (air-dried)	Found	Recovery (per cent)
205	210	102
308	280	91
411	395	96
514	500	97
616	595	97

The method also works well for filter paper, and possibly also for other suitably purified forms of cellulose.

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Action of Solvents on Dried Linseed Oil Films

The action of a range of organic solvents on aged linseed oil films, both pigmented and unpigmented, has been investigated[1]. A specially designed apparatus based on the parallel plate viscometer was used[2] to make precise measurements of changes in thickness of films coated on a rigid substrate, while free films (these proved to be isotropic in behaviour) were observed under a measuring microscope. The results

thus obtained, together with related gravimetric measurements, made it possible to determine rates of swelling and deswelling, and to examine the characteristics of the leaching process in which constituents of low molecular weight are removed when the felt-like structure is swollen.

From such observations support is given to the random, amorphous structure concept for linseed oil films[3,4]. It is probable that, due to solvent penetration, the molecular network of triglycerides is given greater freedom and the units of lower molecular weight actually diffuse out into the solvent phase.

The result of leaching and deswelling was a film of greater density with altered swelling characteristics. Thus it was possible to prepare, from films 40μ thick, aged 44 weeks at 32° C., films ranging in density from $1{\cdot}150 \pm 0{\cdot}002$ to $1{\cdot}170 \pm 0{\cdot}002$ gm./cm.^{3} by exposure to solvents of increasing swelling power. When these films were immersed in methyl alcohol, the corresponding degrees of swelling (volumetric) at equilibrium ranged from $1{\cdot}73 \pm 0{\cdot}03$ to $0{\cdot}56 \pm 0{\cdot}03$ cm.^{3}/cm.^{3}. It was interesting to note that with many types of film, by extrapolating the curves relating the equilibrium swelling and the leached film density, the density of the least soluble triglyceride polymers was found to be close to 1·20 gm./cm.^{3}.

The degree of swelling at equilibrium was found to depend on the solvent used. For a given type of film the results with a variety of solvents were best analysed according to the well-known concept of cohesive energy densities and solubility parameters. (These terms have been discussed by Hildebrand and Scott[4].) Plotting the degree of swelling against the solubility parameter of the swelling solvent results in a 'resonance' curve from the maximum of which the value of 9·3 units was obtained as the solubility parameter for films of dried linseed oil. Solvents which have parameters close to this were found to have great swelling action, for example, chloroform, benzene; whereas those far removed from 9·3, for example, methyl alcohol, or *n*-heptane, had a small swelling action on linseed oil films.

The method of measurement also enabled rates of swelling or diffusion to be investigated, and it was found that Fick's law of diffusion for a semi-infinite solid in the form: $(h_t/h_\infty) = K_s\sqrt{t}/H_0$, applied up to 0·6–0·8 of the swelling maximum. Here h_t, h_∞ refer to the changes in film thickness for supported films at the times t and infinity, and H_0 refers to the unswollen film thickness. A similar equation to this was found to apply to the deswelling data for linseed oil films, and from the constants K_s and K_d (*s*, swelling case; *d*, deswelling case), obtained graphically, it was possible to measure the mean diffusion coefficient $\overline{D}$ from: $\overline{D} = \frac{\pi}{8}(K_s^2 + K_d^2)$, as proposed by Prager and Long[5]. The diffusion coefficients were found to be related to the kinematic viscosity of the solvent through empirical equations of the form: $\overline{D} = B\{\exp(\lambda\rho/\eta) - 1\}$, where ρ/η is the reciprocal kinematic viscosity (c.g.s. units), while B and λ are empirical constants. The effect of increasing the viscosity of the solvent was therefore to decrease rapidly the diffusion coefficient. Thus for pigmented stand oil films aged for eight weeks at 32° C. (81·0 per cent $2PbCO_3.Pb(OH)_2$ by weight in films before solvent treatment) the values of $\overline{D}$ were found to be 5×10^{-6} and $2{\cdot}3 \times 10^{-7}$ cm.^{2}/min. respectively for benzene and *iso*butyl alcohol at 22° C., where the corresponding values of ρ/η were 140 and 22 c.g.s. units.

The effect of temperature was also investigated, and it was found that by raising the temperature the rate of diffusion of solvent was markedly increased. From graphical plots of ln $\overline{D}$ against $1/T$ (T, the absolute temperature), it was possible to evaluate the activation energies of sorption, which were found to be in the range of 5–9 kcal./mole. The magnitude of these energies suggests that the diffusion process in linseed oil films is a straightforward physical absorption of solvent. The diffusion results for pigmented and unpigmented films were compared, and it was found that the effect of pigmentation was to slow down the progress of diffusion due to the impedance of the pigment particles.

I am very grateful to Mr. S. Rees Jones, lecturer-in-charge of the Technology Department of this Institute, for his interest and advice in this investigation, a fuller account of which will be published elsewhere.

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A Device for concentrating and eluting the Spots from Chromatograms

Considerable difficulties are encountered in the elution of spots or zones from paper chromatograms when the substance to be eluted has a low solubility, or when a large number of papers containing small amounts of substance have to be eluted simultaneously.

In the course of work on the fractionation of ^{14}C-labelled cell extracts by electrophoresis[1], it was necessary to extract completely, in as concentrated a solution as possible, the zones obtained from a series of eighty electrophoretic runs in a single experiment. The simple and very efficient device used in these experiments is shown in Fig. 1.

Ten similar spots to be extracted and concentrated simultaneously are superposed in two groups of five spots; one group is replaced on one side of the Whatman No. 20 paper (140 mm. × 30 mm.), and the other group on the opposite side of the same paper. This pile is then pressed between two 'Perspex' plates (2 mm. thick, 120 mm. × 40 mm.), the tip of the Whatman No. 20 paper protruding on one side. The plates are pressed together with rubber bands. The strip of Whatman 3*MM* paper, which serves as a wick for feeding the solvent, is then inserted; a strip of 'Cellophane' 120 mm. wide is tightly wrapped several times around the 'Perspex' plates, and is held in position by rubber bands. This prevents solvent evaporation from the sides, establishing a vapour-saturated atmosphere between the 'Perspex' plates.

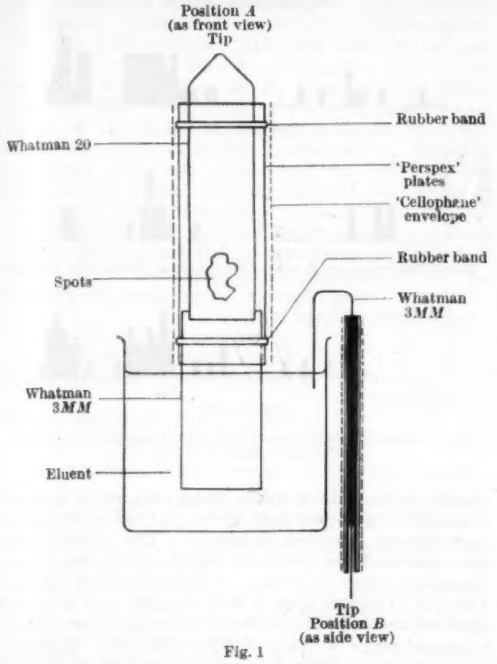

Fig. 1

Holding the apparatus with the point upwards (position *A*), the ascending solvent evaporates from the tip, and passing through the spots elutes and draws the substance into the tip of the Whatman No. 20 paper. After all the substance has been concentrated in this way (usually left overnight), the apparatus is turned downwards (position *B*) and the substance is eluted from the tip by the descending eluant in the smallest possible amount of solvent dripping slowly from the paper. If necessary, the apparatus can stand in a box through which an inert gas can be perfused.

Experiments with dyes and other coloured substances have shown the high working efficiency of this device.

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Cleavage in Chromium of High Purity

During a study of the brittle fracture of chromium, we have made the following observations concerning cleavage in electro-polished test-pieces which were cut from ingots of argon arc-melted electro-deposited metal of high purity and fractured in bending at room temperature.

Cleavage occurs principally on {100} crystallographic planes, but in many grains {112} cleavage is also present. These two types of cleavage are readily distinguishable by microscopical examination of the fracture surface; the {112} cleavage being in general restricted to small areas which appear as specular plane surfaces relatively free from crystallographic markings and other irregularities of the type exhibited by the {100} cleavage facets. Less clearly defined cleavage also occurs on other crystallographic planes.

The {100} cleavage surfaces show certain features which appear to have been observed previously only in the fracture of glass and other non-metallic materials. For example, a smooth 'mirror' surface (the smooth, relatively flat, area adjacent to the point of origin of a fracture surface in glass is always referred to as the 'mirror' of the fracture) may be present at the origin of the cleavage facet; on the 'mirror' and other smooth portions of the {100} facets two sets of curved parallel lines, identical with the Wallner lines[1] which frequently occur on fracture surfaces in glass, have also been observed. These lines originate at non-metallic inclusions or other defects in the metal which set up transverse elastic waves when the fracture front passes through them. The wave travels outwards with a constant velocity (which is a function of the physical properties of the metal) and continuously intercepts the advancing fracture front, thus momentarily deflecting the plane of cracking and producing two curved lines on the fracture surface which radiate from the originating inclusion or flaw.

The geometry of these lines shows the relationship between the velocity of fracture and the velocity of the transverse elastic wave. Smekal[2] and Shand[3] have given methods for determining the fracture velocity in glass from measurements made on the lines. In the case of chromium, the matter is complicated by the fact that the velocity of the transverse wave appears to vary with the crystallographic direction. It is clear, however, from the geometry of the lines that the speed of fracture increases across the 'mirror' surface to a value approximately two-thirds that of the transverse elastic wave in the direction of propagation of fracture.

It has also been observed that thin filaments may be produced during cleavage; these are generally attached at one end to the cleavage facet, and, in contrast to the bulk properties of the chromium test-piece, they show a remarkably high ductility at room temperature.

This communication is published by permission of the Chief Scientist, Department of Supply, Australia. A fuller account of the work will be published elsewhere.

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Latent Energy in Flames

It has been shown[1] that, to bring about ignition in an explosive medium, two conditions must be satisfied, namely, a certain temperature must be reached and a certain quantity of heat supplied. The same criteria govern change of physical state, and this presents an interesting analogy which I hope to develop elsewhere.

It was further indicated that ignition is an endothermic process and that the subsequent exothermic phase of the chemical reaction belongs to the process of flame propagation rather than to that of flame

generation. There is, therefore, a latent energy factor in ignition which corresponds to latent heat in change of state. This term is obviously related to the chemical quantity known as 'activation energy', and is reminiscent of the 'latent energy' concept of the late Prof. W. T. David[3].

Because of this latent heat factor, energy is absorbed when a flame is created and, conversely, energy is released when a flame expires. It is well known that, when a flame reaches the walls of its containing vessel and expires, a sudden flush of heat, sometimes referred to as the 'afterglow', passes through the combustion products. The faster the flame travels, the quicker it is extinguished at the surface of the vessel and the more rapid the release of energy.

A study of the impact of flame on the closed end of a pipe has been made with the aid of piezo-electric pressure gauges, and it has been confirmed that high-speed flames produce a mechanical effect similar to that of a projectile. It is suggested that the familiar phenomenon of 'knock' in an internal combustion engine is due to this cause.

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A New Safflower Oil with a Low Iodine Value

Safflower (*Carthamus tinctorius*) is an ancient crop of India and Egypt. The valuable properties of its oil in the manufacture of paint have recently attracted the attention of agronomists and oil chemists, and commercial production of safflower in several countries has commenced.

As shown in Table 1, safflower oil is typical of oils rich in linoleic acid. Its drying properties are similar to those of linseed oil but superior to the latter, due to its non-yellowing on ageing and its particular suitability for the manufacture of alkyd resins[1].

Oil quality, as expressed in terms of iodine value and component fatty acids, varies with environmental factors such as geographical latitude and altitude[2], day and night temperatures, and amount of rainfall during the periods of flowering and seed setting[3]. These factors may influence the quality of the oil to such an extent that technologically different types of oil are obtained from the same variety of an oil plant when it is grown under extremely different conditions[4]. Under the same growing conditions, however, the composition of a vegetable oil is no doubt characteristic for each species or variety[5], and marked deviation from this rule seems to be very rare indeed. However, such a deviation from the normal was found when assaying a sample of safflower seed grown in 1949 at the Waite Agricultural Research Institute. The original seed was obtained, in 1947, as variety *I.P.* from Pusa Research Institute, India. A normal iodine value of 146 was obtained from a bulk sample of a row, and most of the individual plants from this row showed a normal range of iodine number, 145–148. However, two individual plants had iodine numbers of 105 and 100. The progenies from the latter plant, inbred for two generations, gave iodine numbers ranging from 88 to 97. Similarly, four generations of inbreeding of one of these plants, with an iodine number of 96, produced seed with a range of iodine numbers of 89–98. Thus safflower plants producing an entirely new type of oil with an iodine number of about 90–100 have been found.

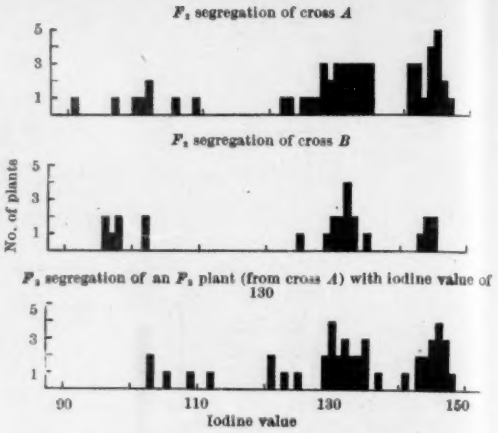

Fig. 1. Iodine values of progeny from two crosses between parents with iodine values of 90 and 141

The plants producing this new type of oil were spineless, 50–60 cm. high, with six to seven capitula, orange florets and relatively small heads, and the chromosome number ($2n = 24$) was the same as that of plants of 'normal' iodine value.

The component fatty acids of some samples of the new type of oil are shown in Table 1, together with the composition of the oil from samples of normal safflower. It can be seen that in contrast to normal safflower oil, the new oil is rich in oleic acid. In this latter respect it resembles olive oil. Of considerable interest also is the fact that the content of saturated acids of some of the oils of low iodine value was very low indeed, but varied considerably.

Thus two technologically different oil types, an edible one and a drying one, were obtained within the same species. Apart from the commercial possibilities of the new oil, the broad differences in composition of the two types of oil make the material eminently suitable for studies on the inheritance of oil quality and possibly also on the biosynthesis of saturated and unsaturated fatty acids.

The results of two crosses between 'normal' and 'variant' safflower are illustrated in Fig. 1. These indicate that the iodine value may be controlled by a single gene, with incom-

Table 1. Composition of Normal Safflower Oil from a Number of Sources in Comparison with Variant Type

Type	Origin	Iodine value	Component fatty acids				Reference
			Saturated (per cent)	Oleic (per cent)	Linoleic (per cent)	Linolenic (per cent)	
Normal	United States	145	6	26	68	Trace	Hilditch, 1951
,,	Kenya	143	10	13	77	—	,,
,,	South Australia	148	6	15–22	72–79	0	
Variant	South Australia	91–101	4–8	74–79	11–19	0	

Note: The South Australian safflower oils were analysed spectrophotometrically.

plete dominance in the heterozygote. The numbers of 'variant' (iodine value, 90–112), 'intermediate' (121–137) and 'normal' (141–148) were 15, 41 and 24 respectively in the F_2 generation, and 5, 23 and 16 in the F_3 from an F_2 plant with an iodine value of 130. Two other F_2 plants, with iodine values of 125 and 128, showed a similar distribution of iodine values in the F_3 segregation. Whether modifying genes are influencing the effect is not clear at this stage; but in view of the accepted complexity of biosynthetic processes leading to the formation of non-saturated acids, it would seem surprising that the predominance of linoleic or oleic acid in safflower oil is determined by the homozygous condition of a single gene.

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Absorption Changes induced by the Photochemical Reaction of Photosynthesis

If a series of flashes of bright light is given to a suspension of green algae, the primary photoproduct and subsequent intermediates will be largely removed in the course of each interposed dark period, if its duration is sufficiently long. At room temperature a dark-time of about 50 msec. will be a minimum[1].

If one or several of the intermediates involved are pigments changing their absorption spectrum in the course of the reactions, the cyclic variations of the optical density will be most pronounced if a suspension of algae is exposed to these flashing-light conditions. On the basis of this principle, we have looked for the occurrence of such fast absorption changes with the view of correlating them with our studies of photosynthetic oxygen exchange under comparable conditions of steady-state flashing light.

The apparatus used for illuminating the algae was the same as that used in our earlier work with flashing light. The reaction vessel, instead of being connected with the microvolumeter, was placed behind the exit slit of a monochromator and thus was cross-illuminated by weak monochromatic light in addition to the strong intermittent light from a mercury arc. The monochromatic light, after passing the reaction vessel, was collected on to the sensitive area of a photocell. The rotating disk was provided with a small metal blade, which acted as a shutter, briefly shutting off the photocell each time the bright flash irradiated the algae. The photocurrent, after amplification, was fed into two channels, each of which was opened electronically only during an adjustable time interval, at any desired point of the cycle. One channel was invariably open during the last fraction of the dark-time (just before the flash); the other one, for the experiments reported below, was open immediately after the flash. The output of the two channels was finally compared and recorded via a difference amplifier.

In principle, the method described allows wide variation of the various constants involved, such as duration of flash- and dark-time, intensity of flash and arrangement in time of the observation points during the cycle. Fluorescence induced by the flash does not interfere. Chemiluminescence will be seen by the photocell and also 'after-changes', which occur eventually, of the intensity of the fluorescence caused by the measuring light beam. But these phenomena, if at all perceptible or existent, will influence the readings rather independently of the wave-length of the measuring light. Therefore, only changes in light-absorption (and only those persisting for less than a complete cycle) will cause deflexions of the recorder, dependent upon wave-length.

We may briefly describe the difference spectra observed with green algae over a wave-length range extending from 400 to 730 mμ. The major effects, illustrated in Fig. 1, are observed consistently, but considerable quantitative variations are found between different strains and also between different samples of the same strain.

In the range of short wave-lengths, the observed absorption changes are roughly comparable with those described by Duysens[2], Lundegardh[3], Witt[4] and

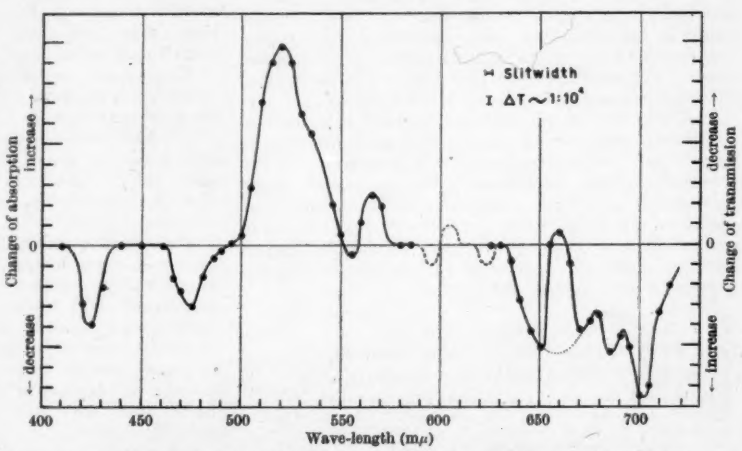

Fig. 1. Changes of absorption induced by strong light-flashes in suspensions of *Scenedesmus* sp. Measurements were made at intervals of 5 mμ; the differences observed in four experiments were averaged and plotted as a function of wave-length. The light transmission of the suspension immediately before each flash was compared with the transmission immediately after it. The 'observation times' were 4 msec., the flashes lasted 0·5 msec., while the dark-time was 60 msec. For each wave-length the photo-current was adjusted to the same value and the changes of this current ΔT are expressed as a fraction of this uniform signal T

Spruit[5] under conditions of either continuous or intermittent illumination.

The minima at 423 and 555 mμ (the latter is sometimes more pronounced than in Fig. 1) could indicate that oxidation of cytochrome *f*[6] is closely related to the photochemical photosynthetic reaction. The increase of absorption around 565 mμ might indicate a simultaneous reduction of cytochrome b_6 described by Hill[7]. The absorption changes in the region 460–550 mμ are very pronounced; the intensity and the shape of the bands may show significant variations. At least two, but probably three, components contribute to the increase of absorption around 520 mμ.

Between 570 and 640 mμ no changes at all are often observed; but in several instances significant effects such as those indicated by the dashed curve were found.

The changes in the red spectral region are large and very detailed. Fig. 1 shows maxima of decreased absorption at 650, 670, 685 and 703 mμ. At 660 mμ a sharp positive peak looks as if it were superimposed on the broad negative shift in the same wave-length region (as indicated by the dotted line in Fig. 1).

The maxima and minima indicated were observed in all experiments, although there was a great deal of variation in relative intensity. A prolonged series of observations or exposure of the algae to bright light (conditions which cause photo-inhibition) may induce decreased changes, but that around 700 mμ is affected to a lesser extent, being shifted a few millimicrons to the longer wave-lengths. Two strains of *Chlorella* showed relatively smaller changes at 700 mμ; either the shift at 650 mμ (cf. ref. 8) or those around 680 mμ (cf. ref. 9) were most prominent. In Fig. 1 the change at 520 mμ is drawn as having about the same magnitude as that at 703 mμ; more generally, however, the first one is much (two to three times) higher.

Preliminary experiments, in which the time of observation succeeding the flash was varied, indicated that the time courses of the major changes are roughly similar and characterized by half-times of the order of 5 msec. at room temperature. The flash intensity required for yielding the maximum effects was quite high and comparable to the intensity required for obtaining flash saturation in oxygen exchange measurements under comparable conditions. These changes therefore are probably closely correlated with the primary photochemical reaction (cf. ref. 1).

The shift at 703 mμ may indicate the existence of a hitherto unknown pigment, probably present in very small concentration. Disappearance of its absorption might be caused by energy transfer from chlorophyll *a*. The complexity of the difference spectrum largely prohibits further interpretation and requires a more detailed analysis. A detailed paper including difference spectra of various photosynthetic organisms will appear shortly[10].

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Near-Eastern Equine Encephalomyelitis

During intermittent investigations of encephalitis of horses and donkeys in Egypt and Syria, spread over the past six years, we have isolated from infected equines and other hosts twenty-three strains of virus which, in respect of pathogenicity for laboratory animals and other characters so far determined, are indistinguishable. The equine disease, which is apparently carried by arthropods, conforms broadly to earlier descriptions of equine encephalomyelitis in the Middle East[1–3]; and, recently, we have recognized three outbreaks of encephalitis in sheep and one in cattle from each of which strains of virus, indistinguishable at this stage from the equine strains, have been isolated.

In equines the important lesions are confined to the central nervous system. Marked congestion of the superficial cerebral vessels and the sinus transversalis is common. Histologically, one finds congestion, lymphostasis, perivascular cuffing and diffuse infiltration by lymphocytes, mobilization of microglia, satellitism and neuronophagia by microglia and lymphocytes. Joest–Degen bodies have not been found. Lesions are most pronounced in the cerebral cortex, hippocampal area, pons and medulla. They occur less commonly in the grey matter of the cord, and scarcely at all in the cerebellum. This description applies equally to lesions of the central nervous system in all host species, whether naturally or artificially infected.

Initial isolations of virus have been made in rabbits, day-old chicks and a guinea pig by subdural inoculation; in eggs after one or two blind passages in the yolk sac; and in kittens fed on infective brain. Recovered strains of virus cause encephalitis in rabbits, infected subdurally or intramuscularly, after incubation periods of a few days to several weeks. Serial passage of fresh material in young rabbits generally shortens the average incubation period to less than 15 days. Symptoms, apart from loss of weight, are not apparent until a few hours before death, when paralysis in extension, clonic spasms, paralysis of the bladder, and occasional somersaulting may be observed. Inoculated day-old chicks usually show somnolence and ataxy, and die between the fourth and sixth days.

Kittens infected *per os*, after an incubation period of 11–22 days, show stomatitis, head tremors, ataxy, for a period of 24–72 hr. before death in convulsions. The capacity of strains isolated from equines and wild birds to infect kittens by the mouth suggests that the equine disease may be identical with the Kazakstan equine encephalitis of Russian workers[4].

Two lambs infected subdurally with a rabbit-passaged horse strain died of encephalitis after 35 and 95 days, while two yearling sheep inoculated subdurally with brain from naturally infected sheep developed symptoms after 5 and 15 days. In each case virus could be transferred in rabbits serially. We have not yet succeeded in unequivocally reproducing the disease in horses, but in both sheep and horses there may be viræmia for considerable periods after inoculation.

All strains are readily filtrable through Seitz *EK* or Chamberland *L5* filters. After preliminary clarification four strains of varied origin have passed 'Gradocol' membranes ranging from 94 mμ to 34 mμ a.p.d., and only in one instance was there an indication that the end-point was being approached.

The virus is not particularly labile and will survive in normal saline suspensions, containing penicillin and streptomycin, for some weeks at + 2° C. It can be preserved for at least a year as frozen tissue at − 30° C., and freeze-dried material was still viable after 3½ years at − 30° C.

Three outbreaks in horses began in early spring and subsided spontaneously in May or early June. Of possible vectors in the area it seemed that only the over-wintering adults of *Hyalomma excavatum* were likely to be active as early as February; and that the feeding of hibernating adults, followed by that of adults newly moulted from hibernating nymphæ, would in all probability continue to the end of May. Systematic monthly collections of ticks confirmed this hypothesis, and inoculation of extracts of unfed ticks resulted in isolations of virus in rabbits and eggs. Virus was also shown to pass transovarially to the larvæ of *H. excavatum*.

Since larvæ and nymphæ of *H. excavatum* have been taken from nestling birds, wild birds, particularly aquatic species, were collected in an infected area in Syria, and pooled suspensions of brain were inoculated into rabbits or fed to kittens. In this way virus was recovered from *Ardea p. purpurea, Ardeola ralloides, Ardeola ibis ibis, Egretta g. garzetta, Oriolus oriolus, Glareola p. pratincola, Sturnus vulgaris* and others.

It was our intention to compare all these strains serologically, and for this purpose rabbits had recently been repeatedly inoculated with adjuvant vaccines. It was also intended during the present season to try to effect tick transmissions; but political developments have necessitated the postponement of our plans, perhaps for some considerable time. The disease in sheep is not uncommon in Syria, and since in the past two years outbreaks have been both frequent and extensive it is probably economically more important than the disease in equines. It is largely on this account that we have prepared this preliminary communication.

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Uptake of Radioactive Zinc *in vitro* by the Prostate

A high concentration of zinc has been demonstrated in the prostate gland of many animals, especially in the dorso-lateral lobe of the rat[1], in human prostate[2] and spermatozoa. Because the radioactive isotope of zinc (zinc-65) at present available has a half-life of 250 days, it is unsuitable for studies in man, with the possible exception of cases with advanced malignant disease[3].

Slices of dorso-lateral lobe of rat prostate, liver, muscle and other tissues have been incubated in buffered Krebs–Ringer phosphate at 37° C. in a Warburg apparatus. They show a steady oxygen uptake, and added zinc-65 with carrier is taken up by the tissues in concentrations relative to those obtained after injection of the isotope into the intact animal. Fig. 1 shows the result of such an experiment.

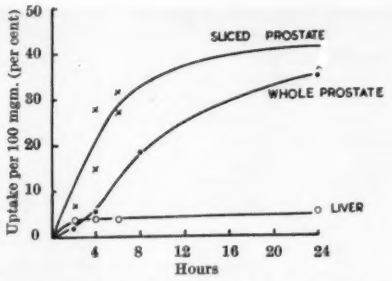

Fig. 1. Zinc-65 taken up by rat prostate and liver *in vitro*

Human prostate obtained at surgical operations has been taken to the laboratory in ice and slices incubated in a similar manner. The tissue, which has usually been removed because of benign hypertrophy, shows a marked concentration of the isotope at 4 hr., and autoradiographs have been prepared from the slices.

This technique offers an acceptable method of studying zinc metabolism in human prostatic disease.

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Histological and Histochemical Changes in Gamma-irradiated Lima Beans, *Phaseolus lunatus*

Clark's Bush variety of lima bean was grown on the farm of Farmington Experiment Station, Farmington, Utah; pods were harvested when beans were in the prime canning stage and were placed and sealed under vacuum in No. 10 tin cans. Each can was labelled, indicating the dose of gamma-rays to be given. The cans thus prepared for irradiation were transported under refrigeration (40° F.) to the National Reactor Testing Station, Arco, Idaho. The radiation used in the experiment was from a source of active spent fuel rods. Irradiation was by exposing the spent fuel rods from the reactor in a canal containing approximately 18 ft. of water. The rods were placed under columnar racks, and the cans containing lima beans were placed on the racks. The rate of irradiation was 1×10^6 rep/hr. at 78° F. The beans received the following doses of radiation: 0×10^6 (control), 1×10^6, 2×10^6, 4×10^6, 8×10^6, 10×10^6, 20×10^6, 40×10^6, 60×10^6, 70×10^6, 80×10^6 and 100×10^6 rep.

Following irradiation, the cans were returned to the Horticultural Research Laboratory, where some of

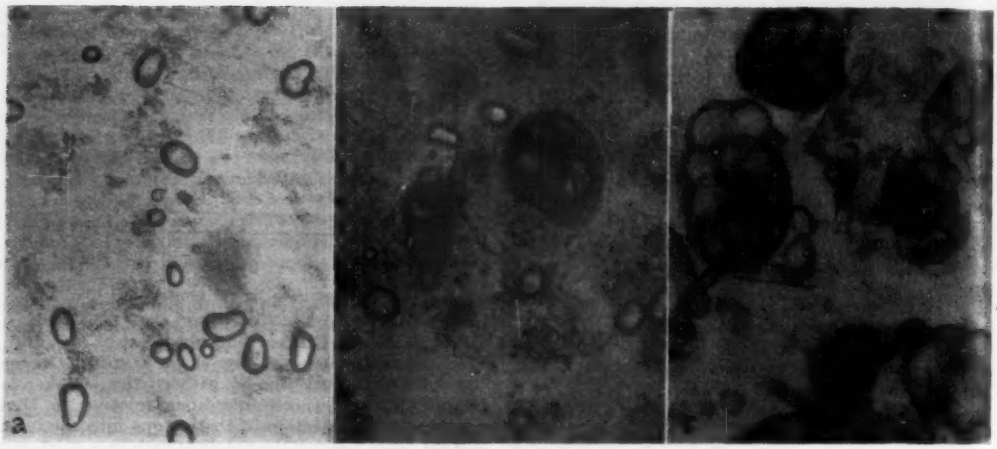

Fig. 1. Effect of irradiation of lima beans on the liberation of starch grains from the cells of cotyledons. *a*, Unirradiated (control), starch grains liberated readily from most of the cells; *b*, radiation dose 10×10^6 rep, some starch grains liberated; *c*, radiation dose 100×10^6 rep, very few starch grains liberated. × 100

the pods from each can were preserved in 95 per cent ethanol for histological and microscopic studies. From the remaining pods, the beans were separated, and a slurry of beans was prepared with a Waring blendor in 95 per cent ethanol for chemical analyses.

After irradiation, the normal green colour of the pods of lima beans was faded, and the reduction of colour was directly correlated with the amount of radiation received. Apparently the chlorophyll content was degraded progressively as the intensity of the radiation increased. Similarly, the turgidity of the pods was decreased. At the higher doses (40×10^6 to 100×10^6 rep) of radiation, pods were split at the dorsal and ventral sutures and the beans were detached. The greenish-white colour of cotyledons had turned progressively brown from 8×10^6 to 100×10^6 rep. This browning may be the result of the condensation of soluble nitrogenous and sugar fractions which are formed upon the hydrolyses of proteins and carbohydrates, or probably in the carmelization of sugars or perhaps be due to the catalytic effect of certain components on the process of the carmelization in beans at high doses (more than 8×10^6 rep) of radiation.

Microscopic examination of cells and cell structures of the beans showed that the cells had separated from each other when the dose (more than 2×10^6 rep) of radiation increased. This may be due to the partial or complete destruction of the constituents of the middle lamellæ. The starch grains were liberated readily from the cells of unirradiated beans. However, the liberation of starch grains from the cells of radiated beans was inversely proportional to the amount of radiation (Fig. 1). The walls of the cells of radiated beans were rather elastic and not easy to break open. No noticeable effect of radiation on the size, shape, hilum and lamellæ of starch grains was seen. In addition, the protoplasm within the cells appeared unchanged even at the highest dose (100×10^6 rep) of radiation. Nevertheless, the intercellular continuity of cytoplasmic strands might have ceased.

Chemical analyses (to be published in detail elsewhere) showed that the amount of reducing sugars and total sugars in beans was increased, approximately in the same proportion as the starch (especially amylose) content was decreased, as the dose of radiation increased. This concurs with the findings of Roberts[1]. She reported that the threshold value of irradiation, by high-energy cathode rays, producing changes on potato starch was approximately 5×10^6 rep. At this radiation dose, traces of fructose, glucose, and dextrin were noticed. The conversion of starch to sugar may result from progressively accelerated enzymatic action and/or chemical breakdown in the beans. A slight reduction in the protein content of the radiated beans was observed, but it was not significant.

My thanks are due to Dr. P. H. Krumperman for making the necessary arrangements for the irradiation of lima beans and to Dr. W. S. Boyle for taking the photomicrographs.

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Influence of Illumination on the Synthesis of Leuco-Anthocyanins in Leaves

Recently, Phillips[1] suggested that the controlling factor in lignification in home-grown ash (*Fraxinus excelsior*) is the illumination received by the leaves. A coppice shoot of ash was hooded at various times during the growing season, and when sections of the stem were afterwards examined, it was found that poor lignification (in the botanical sense) coincided with the periods of shading.

It has been shown that the occurrence of leuco-anthocyanins in leaves is closely associated with a woody habit in plants[2], and that such leuco-anthocyanins are possible precursors of heartwood extractives in *Eucalyptus* spp. in which their concentration in leaves varies throughout the season[3].

Table 1. METHANOL-SOLUBLE LEUCO-ANTHOCYANINS AND TOTAL PHENOLS (MGM./GM. DRY WEIGHT) IN 4–4½-IN. LEAVES OF THE VICTORIA PLUM TREE

Date of collection	On sunny side		On shady side	
	Methanol-soluble leuco-anthocyanins	Total phenols	Methanol-soluble leuco-anthocyanins	Total phenols
1956				
May 28	29	113	21	94
June 20	41	128	31	109
July 3	63	124	40	90
July 23	42	110	21	108
August 8	36	112	24	90
October 15	33	100	31	74

We have now shown that their synthesis in the leaves of the Victoria plum (*Prunus domestica* var. Victoria) is markedly affected by illumination. Samples of leaves from the shady (north) and sunny (south) sides of one tree of Victoria plum were collected at two- to three-weekly intervals throughout the season May–October 1956. The leaves were extracted exhaustively with methanol within two hours of collection and the content of leuco-anthocyanin and total phenols of the extract determined (unpublished results). Leaves of the same size, taken from high or low branches on the same side of the tree, showed little difference in leuco-anthocyanin or total phenol content on either a dry-weight or total-extractives basis. However, leaves from the shady side of the tree were found to have a markedly lower content of leuco-anthocyanins, and to a lesser extent total phenols, than leaves of similar size from the sunny side (see Table 1). The inconsistent results for leucoanthocyanin in the leaves on the shady side (July 23–August 8) may be associated with the rapid growth of fruit which took place at that time.

Illumination was shown to be responsible for the difference in analyses by shading experiments. Small branches on the sunny side of the tree were shaded with black paper and the leaves from these branches harvested with the next sample collection. The increase (20 per cent) in leuco-anthocyanin in the first batch of leaves (shaded June 20) was much less than the increase (55 per cent) in the unshaded leaves. Similar results were obtained in experiments on a second tree growing in a different locality.

It should be noted that the leuco-anthocyanin content of the leaves on the sunny side increases and then decreases during the course of the season. This is due to an increasing portion of the leuco-anthocyanins being rendered insoluble in methanol, as the production of anthocyanidin from the methanol-extracted residue on digestion with acid increases throughout the season (unpublished results).

The second batch of leaves was shaded on July 23, when the leuco-anthocyanins in the unshaded leaves had begun to become insoluble in methanol. In this case the decrease (10 per cent) in methanol-soluble leuco-anthocyanins in the shaded leaves was much less than the decrease (29 per cent) in the unshaded leaves.

The dependence of leuco-anthocyanin synthesis in the plum leaf on illumination is paralleled by lignin formation in the stone (endocarp) of the fruit. Stone in the fruit from the shady side showed a slower hardening, as judged by ease of dissection, than that from the sunny side.

It is felt that the results of these experiments point to a correspondence between lignification and formation of leuco-anthocyanin which may lead to a better understanding of the metabolism and biosynthesis of aromatic compounds in woody species.

The work described in this communication was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research, and the Division of Forest Products, Commonwealth Scientific and Industrial Research Organization.

We wish to thank Drs. E. C. Bate-Smith and E. W. J. Phillips for helpful discussions.

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Inhibition of Acetylcholinesterase by Reserpine in Suspension

IN the routine examination of compounds as possible inhibitors of enzymatic reactions, it appears to be fairly common practice to ignore that part of the added compound which remains in suspension in the reaction flask when the limits of solubility have been exceeded. Any inhibition which may be observed is thought to be due to the portion in solution. The necessity to remove the insoluble material from the system has been made clear in the course of a study to determine if reserpine would act as an inhibitor of acetylcholinesterase.

The enzyme was derived from bovine erythrocytes (purchased from Nutritional Biochemicals Corp., Cleveland, Ohio) and its activity was measured manometrically by the method of Ammon[1]. Various amounts of reserpine were tipped into the reaction flasks so as to yield concentrations of 10^{-3}, 10^{-4} and 10^{-5} *M* if complete solution had occurred. The results showed inhibition of 75–80 per cent at 10^{-3} *M*, 20–25 per cent at 10^{-4} *M* and 5–10 per cent at 10^{-5} *M*. Close examination of the reaction flasks, however, showed the presence of visible suspensions when the two higher concentrations of reserpine were used. While no suspension was visible for the lowest concentration of reserpine, it was afterwards found that appreciable quantities of reserpine had been adsorbed on the glass. Since the presence of insoluble reserpine indicated that the medium of each flask was saturated with the alkaloid, it was difficult to explain the differences observed in the degree of inhibition of the enzyme. The amount of reserpine in suspension appeared to be the only real variable in the experiment and was immediately suspected as being the cause of the inhibition. To eliminate the insoluble material from the system, the buffer was incubated with reserpine for 15 min. at 37° C., filtered and added to the reaction flasks containing the enzyme in the side-arm. Analysis of the buffer solutions by measuring the absorption at 268μ showed that all were saturated with reserpine. Under these conditions no inhibition of the enzyme could be observed. It should also be noted that no inhibition was observed for the acetylcholinesterase activity of homogenates of the brains of guinea pigs killed at either 20 min.

or 4 hr. after the intravenous injection of 5 mgm./kgm. of reserpine. It may be concluded, therefore, that reserpine has no inhibitory action on acetylcholinesterase.

In order to obtain some insight into the nature of the interaction between the enzyme and the suspended reserpine which resulted in inhibition, these materials were mixed with buffer and the insoluble material filtered off. The supernatant was tested for acetylcholinesterase activity and was found to be devoid of active enzyme. The insoluble material was resuspended in buffer and extracted with toluene. Only one-third of the total reserpine was extracted and no enzyme activity was released. The remainder of the reserpine was extracted with chloroform but still no active enzyme was released. All that remained of the insoluble mass after the chloroform extraction was a slight filmy precipitate. It should be noted that shaking a solution of the enzyme with toluene has no effect on its activity, and shaking with chloroform reduced the activity by only 10 per cent. It appears, therefore, that reserpine crystals adsorb the acetylcholinesterase on their surface, resulting in denaturation of the protein and loss of activity.

While it is not possible to state whether this phenomenon has general application, we have observed it to occur with the alkaloid ibogaine, which may explain the results reported by Vincent and Sero[2] concerning the inhibition of serum cholinesterase by ibogaine.

In conclusion, one must emphasize the need of working within the limits of solubility when studying the effects of a substance on enzyme activity.

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Antistaphylococcic Factors in Brain Extract

Our colleagues, Nutini and Lynch, have shown[1] that a crude extract (prepared by freezing and thawing ox brain, centrifuging, precipitating proteins with 95 per cent ethanol, filtering and concentrating *in vacuo*) was very effective in the prevention and treatment of *Staphylococcus aureus* (*Micrococcus pyogenes*, var. *aureus*) infections in mice. *In vitro*, the extract was found to stimulate the growth of the organism on nutrient agar, with conversion of the orange or yellow *S* variety to a white *P* configuration[1d], and to inhibit toxin formation by the organism[1a]. We wish to report investigations on the concentration and characterization of the active factors in the extract. Effectiveness of the fractions was evaluated in terms of the dose which protected mice from death by *S. aureus* infection, using a combined prophylactic-therapeutic procedure based upon that originally described[1a].

The active material is essentially stable between *p*H 2·5 and 9 and to heat. It is soluble in water and the more polar solvents. Percolation of the crude extract through the strong cation exchange resin, 'Amberlite *IR*-100', followed by elution with dilute pyridine increased the activity ten-fold with a yield of about 10 per cent and with the removal of inactive inorganic salts which constitute up to 40 per cent of the crude extract. Elution with *N*/4 hydrochloric acid from the strong anion exchanger, 'Amberlite *IRA*-400', also gave a potent preparation. These properties, confirmed by other reverse deionization procedures and by percolation through a mixed bed followed by separate elution after back classification, suggested an amphoteric substance.

Paper chromatography revealed the presence of amino-acids (aspartic acid, glutamic acid, glycine, alanine, arginine, histidine, and γ-aminobutyric acid) and peptides. Separation of the pyridine eluate from '*IR*-100' into amino-acid fractions by chromatography on cellulose columns did not achieve notable concentration of activity; γ-aminobutyric acid was the main constituent of the most active fraction. Chromatography on alumina also failed to concentrate the activity. Elution with dilute pyridine from the weak cation exchanger, '*IRC*-50', gave a fraction of comparable *in vivo* activity which contained about 10 per cent of γ-aminobutyric acid as the only ninhydrin-positive material. Pure γ-aminobutyric acid was ineffective against experimental staphylococcus infections. Thus, ninhydrin-positive materials did not appear to be responsible for the activity of the extract.

Acidic and basic substances were demonstrated in crude brain extract and the pyridine eluate from '*IR*-100' by paper chromatography using *n*-butanol/acetic acid/water (4 : 1 : 1)[3] followed by spraying with bromocresol green[3]. Accordingly, crude brain extract was acidified strongly with hydrochloric acid, extracted repeatedly with ether, then made strongly basic and extracted again with ether. The acid fraction (3·5 per cent of the solid content of the extract) was about forty times as active as the crude extract. The basic fraction (1 per cent of the extract) and the residue (95·5 per cent) were moderately active. Lactic and fumaric acids, identified in the acid fraction by paper chromatography in the ratio of about 10 : 1, were inactive against *S. aureus* infections. Re-extraction of the acid fraction with ether at *p*H 7, 4·5, 2 and 1 in succession produced about a ninety-fold increase in activity in the *p*H 4·5 extract; slight activity was present in the extracts obtained at *p*H 7 and 2, while the *p*H 1 extract was inactive and toxic. In addition to small amounts of fumaric and lactic acids, the *p*H 4·5 fraction contained high concentrations of two unidentified acids which were slightly present in the whole brain-acid fraction.

These two acids, accompanied by traces of lactic and fumaric acid, were separated by developing a strip chromatogram[4] of the *p*H 4·5 fraction with ethanol/concentrated ammonium hydroxide/water (80 : 5 : 15). Insufficient material being available for animal assay, the acid fractions with eight others obtained from the strip were tested *in vitro* against *S. aureus* by the filter disk method, using 'Difco' staphylococcus medium 110. The acid fractions inhibited growth of *S. aureus*, whereas four fractions slightly stimulated the growth. The whole *p*H 4·5 extract, a composite of these fractions, had no effect on growth. Future work will be directed to the study of the active fractions.

Because the original crude extract stimulated the growth of *S. aureus* on nutrient agar[1d], several of the fractions described were tested on the organism, using a nephelometric procedure in a highly supplemented liquid medium ('Difco' leucine assay medium

with added leucine) to minimize the possible nutritional effects of amino-acids and other materials. Crude extract caused an increase of about 35 per cent, whereas the pyridine eluate from 'Amberlite *IR*-100' produced 12 per cent inhibition and the whole acid fraction about 79 per cent inhibition. Since the inhibitory fractions were considerably more potent than the crude extract against infections *in vivo*, it is doubtful whether the growth stimulation originally observed is related to the effectiveness against the infection. The antistaphylococcic activity probably may be attributed to as yet unidentified acid substances.

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A Probable Peptidase in Carcinoid Tumours

CARCINOID tumours (argentaffin carcinomas) are considered to arise from the argentaffin (enterochromaffin, Kultschitsky) cells of the intestine. These tumours contain and secrete 5-hydroxytryptamine[1], and histochemical investigations[2] make it likely that enterochromaffin cells do likewise. In three cases of argentaffin carcinoma recently investigated, we have observed a strong esterase (Fig. 1) capable of hydrolysing a variety of substrates. Using

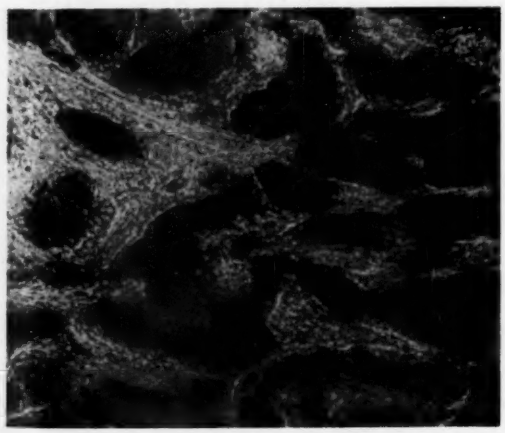

Fig. 1. Frozen section (15μ) of human ileum. Carcinoid tumour infiltrating serous coat. Indoxyl esterase (1½ hr., no counterstain). (× 175)

Table 1. EFFECT OF INHIBITORS ON CARCINOID ESTERASE
(Figures represent visual estimate)

Inhibitor and concentration	Activation (per cent)	Inhibition (per cent)
Diethyl-*p*-nitrophenyl phosphate, $\times 10^{-4}$ *M*	—	100
Silver nitrate, 2×10^{-3} *M*	—	100
Sodium fluoride, $\times 10^{-3}$ *M*	—	—
Sodium taurocholate, $\times 10^{-3}$ *M*	20	—
Cysteine, $\times 10^{-3}$ *M*	30	—
Hydroxylamine, $\times 10^{-3}$ *M*	30	—
Hydrocinnamic acid, $\times 10^{-3}$ *M*	—	—
Sodium dodecyl sulphate, $\times 10^{-3}$ *M*	—	30

O-acetyl-5-bromoindoxyl as substrate and an incubation time of 4 hr., inhibition studies gave the results shown in Table 1.

Inhibition by diethyl-*p*-nitrophenyl phosphate (*E*600) confirms the general identity of the enzyme as a carboxylic acid esterase. Enzymes of this class are known to function as peptidases, and several of the latter can split indoxyl acetates. Although the results with taurocholate and dodecyl sulphate do not exclude the possibility of a lipase, we believe, on the basis of other work[3], that the pattern of activation and inhibition given above indicates the presence of an intracellular peptidase.

Enterochromaffin cells in man, rat and guinea pig could not be shown by histochemical methods to contain any type of esterase or peptidase. We thus have to consider a tumour containing an enzyme which is absent from the presumed parent cell. This is the reverse of what is usually found by biochemical and histochemical methods.

An esterase with similar properties to the carcinoid esterase is found in the mucous-secreting cells of the intestinal glands, and these were believed by Popoff[4] to give rise to enterochromaffin cells. His theory has had little support, the majority of workers subscribing to the neural crest theory of origin. Although our results preclude neither theory, they make necessary a reconsideration of the ancestry of the cells which give rise to carcinoids, and invite speculation as to the connexion of the enzyme with the behaviour of these tumours.

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Acylacrylic Acids and Biological Activity

IT has recently been reported[1] that β-acetylacrylic acid and its (ethyl) ester are rather poisonous to mice, about 1 mgm. given subcutaneously to a 25-gm. mouse being lethal. There was also an increase in leucocytes, which in the case of the ester appear after about three weeks and in the case of the acid after a few hours. In the latter case the effect disappeared after about a day and this increase was assumed to be due to acidosis. This has now been found to be almost certain, because injection of

a neutralized solution caused no clear rapid increase followed by a rapid decrease in leucocytes. However, the poisonous effect with neutralized acid remained almost unchanged, 2 mgm. being lethal.

The acetylacrylic acid in alkaline solution, 0·1 *N* sodium hydroxide (as the esters), shows a change in its ultra-violet spectrum. Acetylacrylic acid dissolved in alkali and kept overnight and then neutralized has now been found to be far less lethal to mice than the free or freshly neutralized acid, 40 mgm. not being lethal. The reaction undergone by the acid in alkaline solution was previously[1] discussed on the basis of *cis*- and *trans*-isomerism and in the case of the *cis* isomer in open or cyclic form, and this question has now been studied also with the aid of infra-red absorption. Benzoylacrylic acid and related aryl acids easily isomerize[2], and this supports the findings made and opens a way to further contributions in the field of *cis-trans*-isomers, cyclic and acyclic forms and biological activity.

The *cis*-β-formylacrylic acid[3] has also been investigated in these respects. Its ultra-violet spectra in acidic and alkaline solution are similar to those obtained with β-acetylacrylic acid. The lethal dose of the formyl compound dissolved in water is about 0·5 mgm. However, there are differences in the infra-red spectra now being investigated. The formyl compound gives absorption maxima at 1,799, 1,765, 1,696 cm.$^{-1}$ and a broad band at 3,400–3,000 cm.$^{-1}$. This seems to be in accord with the presence of a cyclic form[4]. The acetyl compound, however, has not given equally clear information. Further, some experiments with protoanemonin and ranunculin indicate that the lethal dose of the former is somewhat higher than 0·5 mgm. and that of the latter 40 mgm. One has consequently the sequence: protoanemonin about equal to formylacrylic acid, acetylacrylic acid, anemonin[5] and ranunculin in regard to the lethal dose for mice.

To judge from our injection trials, acetylacrylic acid ought to be a rather strong irritant. Regarding the conception of the development of cancer as due to the co-operation of a carcinogenic substance with an irritant[6], it might be worth while to study the action of compounds that carry a site of carcinogenic action as well as a site of irritation within the same molecule. Investigations along this line may elucidate the mechanism of the proposed co-operation; and according to resources available this line will be followed up with aliphatic, isocyclic and heterocyclic 'carcinogenic sites' and an enone as the 'irritant site'. In this connexion the findings regarding antineoplastic effects with compounds with conjugated enones are of importance (cf. ref. 7). Details concerning the results so far obtained will be published elsewhere.

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Polysepta: a New Genus and Sub-Order of Bacteria

Two similar pathogenic bacteria have been described which possess morphological characters so unusual as to merit the description of a new sub-order Polyseptineae, of the order Eubacteriales, according to the morphological classification of Bisset[1].

The first description was that of Bull[2], who isolated from dermatomycosis ('lumpy wool') in sheep in Australia a filamentous Gram-positive micro-organism which he called *Actinomyces dermatonomus*. The generic name was afterwards altered to *Nocardia*. The second species was isolated by Thompson[3] from 'strawberry foot-rot' in sheep in Great Britain, and was at first believed to be related to *Rhizobium*, because of its production of small, motile, coccal swarmers, resembling those found in this genus. Latterly, however, its cellular structure was examined by cytological methods, and was found to be of a most unusual type[4].

In Fig. 1 this structure is shown compared with that of other types of bacteria. Most Gram-positive genera are subdivided by septa or cross-walls at right-angles to the long axis of the cell; *Polysepta* species are unique among known filamentous bacteria in having such cross-walls also parallel to the long axis, so that fission occurs not only in the transverse, but also in the longitudinal plane, resulting in the budding off of motile coccal units which superficially resemble the swarmers of *Rhizobium* (Fig. 2*b*). Such cross-walls at right-angles one to another are otherwise found only in Gram-positive cocci.

Diagnosis: Sub-order, Polyseptineae (filamentous, flagellated, Gram-positive bacteria, with many cells separated by cross-walls both parallel with and at right-angles to the long axis; fission both transverse and longitudinal). One family, Polyseptaceae. One genus, Polysepta (pathogens of sheep, and experimentally of other mammals, causing pustular dermatitic infections. Catalase-positive, weakly fermentative).

Species. *Polysepta dermatonomus*: (*Actinomyces dermatonomus*, Bull, 1929). Causes dermatomycosis ('lumpy wool') in sheep in Australia. Liquefies gelatin and coagulated serum; ferments galactose with production of acid. (The culture of this species

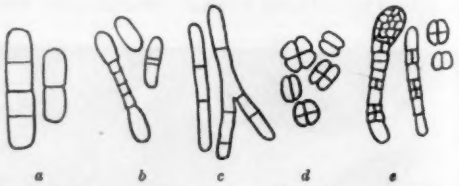

Fig. 1. *Polysepta* compared with other bacterial genera. *a*, *Bacillus*; *b*, *Corynebacterium*; *c*, *Actinomyces*; *d*, *Staphylococcus*; *e*, *Polysepta*

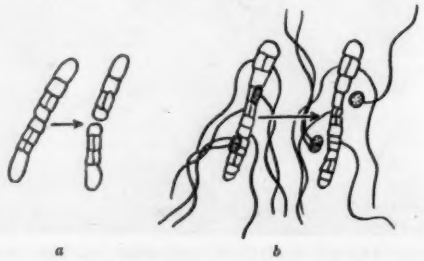

Fig. 2. Division in *Polysepta*. *a*, transverse; *b*, lateral budding

examined by us was kindly supplied by the Director of the Animal Health Station, Yeerongpilly, Queensland, Australia.)

Species. *Polysepta pedis*. Causes strawberry foot-rot in sheep in the United Kingdom. Fails to liquefy gelatin or coagulated serum; does not ferment galactose.

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Relational Incompatibility in Diploid and Tetraploid Lucerne

Cultivated lucerne, *Medicago sativa* L., is a tetraploid ($2n = 32$) and in all probability is an autotetraploid. Both it and its wild, blue-flowered, diploid relative *M. coerulea* Less. display incomplete self-sterility. Genetical situations being so much simpler in diploids, a study was begun at this Institute to see whether a single-locus, multi-allele, oppositional system of self incompatibility was at work in *M. coerulea*, similar to that found in *Trifolium pratense*[1].

The technique used, briefly, was card pollination without emasculation, in an insect-proofed greenhouse. Fertility is expressed as pods per 100 flowers, counts being made some ten days after pollination.

An attempt to distinguish intra-sterile, inter-fertile groups in biparental families showed that if such a system were operating, the degree of illegitimate fertility must be very high, making it very difficult to distinguish compatible and incompatible matings. Attention was then turned to a simpler situation, produced by parent–offspring crossing. This should give families each dividing into two groups, one of them identical with the pollen parent (for example, $S_{1\cdot2}$ ♀ × $S_{1\cdot3}$ ♂ → $S_{1\cdot3}$, $S_{2\cdot3}$).

Typical results for one family, 3♀ × (1 × 3) ♂, are given in Table 1. Crossing with the pollen parent gives higher fertility than selfing, but not as high as crossing with an unrelated plant. There is no sign of a division into two groups distinguishable by degree of compatibility with their pollen parent. It seems very unlikely that a single-locus system of self-incompatibility is at work, but there is an indication that the fertility of a pollination depends on the degree of inbreeding it represents.

The inbreeding coefficients (f) of the zygotes to be produced by the pollinations shown in Table 1 (and others) were calculated on the assumption that the original parents (plants 1, 2 and 3) were neither inbred nor related. The values of f represented were 0, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{5}{8}$; if the original parents were inbred and related, the true values would be higher and less widely separated. For each of four small families (two pairs of reciprocals) the mean fertility for each of these five values of f was estimated, and it was found that there was a linear relation between fertility and inbreeding. The overall means for all families are plotted in Fig. 1. It will be seen that the points depart very little from the (unweighted) least-squares regression line, which has a slope of $-1{\cdot}17$.

Table 1. Fertility of Self- and Cross-pollination in the Family 3♀ × (1 × 3)♂

Plant tested	Self-pollinated				Crossed reciprocally with 1 × 3			
	Flowers	Pods	Per cent	f	Flowers	Pods	Per cent	f
1	137	36	26	$\frac{1}{2}$	138	66	48	$\frac{1}{2}$
2	46	10	22	,,	129	114	89	0
3	160	59	37	,,	195	122	63	$\frac{1}{4}$
1 × 3	80	8	10	,,	—	—	—	—
3×(1×3) 1	79	6	8	$\frac{3}{8}$	120	40	33	$\frac{3}{8}$
,, 2	18	0	0	,,	62	13	21	,,
,, 3	40	5	13	,,	95	28	30	,,
,, 4	33	7	21	,,	58	17	29	,,
,, 5	18	1	6	,,	55	26	47	,,
,, 6	35	4	11	,,	64	23	36	,,
,, 7	55	14	26	,,	211	99	47	,,

It is proposed to use the term 'relational incompatibility' to denote this inverse proportionality between the fertility of matings and the inbreeding they represent.

In the cultivated, tetraploid species, *M. sativa* L., it is already well known that self-sterility increases as inbreeding progresses. The question to be settled is whether the quantitative relation between fertility and inbreeding is the same as in the diploid. This in turn depends on whether the inbreeding coefficient has the same meaning in disomic and polysomic cases. Wright[2] has defined the inbreeding coefficient as the correlation between alleles in the same zygote, in which sense it applies equally to disomic and polysomic cases. Another possible definition is the probability that two alleles taken at random from the zygote are identical (that is, descended from a single allele in some ancestor). In disomic inheritance this reduces to Malécot's[3] definition and gives evaluations identical with those of Wright.

The two definitions also give identical results for selfing polysomics, and so there seems no reason to doubt that the inbreeding coefficient has equivalent meanings in disomic and polysomic cases. But equivalent intensities of inbreeding may have stronger effects on male and female fertility in autopolyploids than in diploids, if only because the former need a more exact control of chiasma formation, having to avoid both univalent and multivalent formation. Whatever the reason, experience of inbreeding *M. sativa* shows that male fertility is often drastically reduced, female fertility more rarely. These effects, which have nothing to do with compatibility, can be minimized by considering either (1) only crosses involving plants the fertility of which is established,

Table 2. Compatibility and Inbreeding in *M. sativa* ($2n = 4x = 32$)

	Generation produced	Year	Flowers	Pods	Mean fertility (per cent)	f (per cent)
(*a*) Selfing and crossing	3rd inbred	1956	2,522	348	13·7	42·3
	1st ,,	1956	354	148	41·9	16·7
	Hybrids*	1956	2,139	1,321	62·0	5·1
(*b*) Continued selfing	4th inbred	1956	1,507	72	4·8	51·9
	3rd ,,	1955	930	156	16·8	42·3
	2nd ,,	1954	569	155	27·3	30·7
(*c*) Continued selfing	5th inbred	1956	740	44	5·9	60·0
	4th ,,	1955	636	101	15·9	51·9
	3rd ,,	1954	437	113	23·6	42·3

* Produced by crossing second inbreds with unrelated non-inbreds.

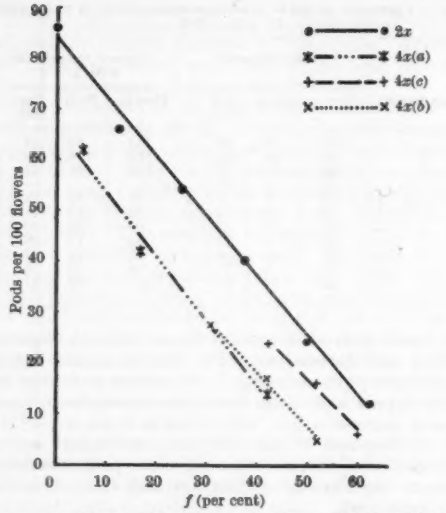

Fig. 1. Fertility and inbreeding coefficient in diploid and tetraploid lucerne

or (2) in continued inbreeding by selfing, only those pedigrees where the most inbred plants are still quite fertile both as pollen and as seed parents.

From the routine records of lucerne breeding work at this Institute, three groups of data are available meeting the conditions specified above and are presented in Table 2. The data for group (*a*) were obtained by crossing second inbred (S_2) plants with unrelated non-inbreds, and by selfing both the second inbreds and the non-inbreds. Groups (*b*) and (*c*) each refer to several pedigrees of routine selfings, performed under comparable conditions. Inbreeding coefficients were calculated assuming that the original parents were not inbred, that segregation is tetrasomic and that double reduction can be ignored. The results are also plotted in Fig. 1. In all three cases there is again a good approximation to a linear relation between fertility and inbreeding, and the regression lines are nearly parallel to that for the diploid material (slope for group (*a*), $-1{\cdot}27$; (*b*) $-1{\cdot}06$; (*c*) $-0{\cdot}99$; unweighted mean, $-1{\cdot}11$). Evidently the same system of relational incompatibility is at work in both tetraploid and diploid lucerne.

Embryological studies by Cooper and Brink[4] showed that the difference in fertility observed when inbred plants of *M. sativa* were crossed or selfed had three causes: (1) foreign pollen tubes penetrated farther into the ovary, (2) they entered ovules more frequently; and (3) after fertilization had occurred there was proportionately less abortion of cross-fertilized ovules. The young endosperm appeared to take a key role in ovule abortion. Relational incompatibility could result from interaction between gametophytes before fertilization (corresponding to cause (2) above) or interaction within and between gametic complements after fertilization (cause (3) above). Self incompatibility is usually regarded as due to an interaction between pollen and maternal tissue (corresponding to cause (1) above) and its genetical consequences are somewhat different, though the distinction might be hard to make in practice. There seems no reason why both relational- and self-incompatibility should not operate in tandem, and further work is therefore needed to assess their relative importance in lucerne.

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Environmental Modification of Œstrus in the Vole

The reproductive processes of the field vole, *Microtus agrestis*, have previously been investigated by Brambell and Hall[1]. Their material was obtained from animals caught in the wild and they concluded that the vole was polyœstrous and exhibited spontaneous ovulation.

Our investigations have been made on voles that have been bred in captivity for many generations, initially at Oxford and more recently, from the same stock, in London also. At Oxford, control stocks of voles were kept in breeding pairs or in groups consisting of a single litter each. For the purposes of experiments on social interactions in vole populations groups of strangers were assembled for varying periods. In London, on the other hand, though breeding was carried out with the voles in monogamous pairs, the weanlings were separated according to sex and the males and females were then kept in groups without regard to litter relationships. During the period of observations, the voles were kept in groups of three or four or up to a dozen, or else as isolated pairs of males and females.

Examination of the vaginal smears of the control animals kept at Oxford gave clear evidence of a regular vaginal cycle though the various phases of the cycle were not as sharply defined as those exhibited by the familiar laboratory rodents. Cornified epithelial cells were generally present throughout but the proportions of these cells, their chromatic properties with hæmatoxylin and Pasini's alcohol stains, and the nature of the other cells present all varied in a regular cyclic manner. Willingness for coitus was investigated by placing male and female voles in a cage that was strange to both animals and watching them closely for periods up to 1½ hr. or until coitus occurred. Œstrus was shown by ready acceptance of coitus, often within the first few minutes: at other times the voles would show no sexual interest. It was found that œstrus could be predicted from the appearance of the vaginal smear, and copulation, succeeded almost invariably by pregnancy, took place at precise stages of the cycle and not at other times. The occurrence of œstrus every third or fourth day was thus clearly demonstrated.

The voles studied in London showed a different pattern of events. There was little evidence of regular variation in the composition of the vaginal smear, which as a general rule consisted exclusively or predominantly of cornified cells, and results were consistent with the idea that the animals experienced prolonged periods of œstrus interrupted occasionally by a dioestrous interval. When female voles were placed with males at any time during an œstrous phase,

fertile coitus usually took place immediately. Neither the examination of the ovaries in histological preparations nor the search for eggs in the Fallopian tube gave any indication of spontaneous ovulation. Moreover, ovulation could readily be induced by the injection of a single dose of pregnancy-urine gonadotrophin, a procedure that has long been successfully employed in the rabbit. In most animals ovulation occurred between 9 and 12 hr. after injection.

We have therefore come to the conclusion that the field vole is capable of showing two kinds of œstrous behaviour: a typical short œstrous cycle as in rats and mice, with sexual receptivity restricted to a particular stage of the cycle, or else prolonged periods of an œstrous state as in rabbits and cats, during which coitus is effected at any time and is associated with induced ovulation. The idea that these two phenomena represent no more than variations of the same basic hormonal pattern has recently been ably expressed by Eckstein and Zuckerman[2], and it is our contention that the hormonal pattern in voles is less rigidly defined than in the other animals mentioned, so that environmental conditions may exert a decisive influence. One of these environmental conditions, namely, the size and composition of a group, is known to produce a variety of effects[3], and it is thought that changes in the vaginal cycle might also occur as a result of 'social stress'. This is supported by the fact that regular œstrous cycles have so far been found only in females living apart from strangers. On the other hand, even under the conditions prevailing in the Oxford colony, prolonged periods of œstrus are found to be typical for unrelated animals living in groups. Even isolated females may not have a cycle, however, and there is reason to believe that the history of the animal is one of the factors that must be taken into account. Our observations suggest that the continuous vaginal cornification in the London stocks may have been induced by keeping the animals in mixed groups.

These investigations are being continued, and it is intended that a full report will be published later.

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Evolution of Nitrogen-fixing Symbiosis in Higher Plants

THE study of nitrogen-fixing symbiosis has been mostly confined to legumes. Other symbiotic associations are known, including members of at least four[1,2], possibly five[3], families of higher flowering plants, and one bryophyte[4]. The root nodules of *Alnus*, *Myrica* and *Hippophae* appear to contain lower fungi[5], but the symbiont responsible for those of *Casuarina* seems ill-defined. The leaf nodules of the Rubiaceae contain bacteria[6], and the liverwort carries the blue-green alga *Nostoc* in exterior sacs in the thallus[4].

The origins of these associations, and the relationships between them, are not known. Bond *et al.*[7] recently suggested that "the *possession of root nodules* and the *ability so to use atmospheric nitrogen* are very ancient characters, and mostly date from a time when only woody flowering plants existed and *when conditions were apparently particularly favourable* to the initiation of symbiotic associations" (my italics). The variety of plants and micro-organisms found in association, and the occurrence of nodulation in all three sub-families of the Leguminoseae[8], support the view that these associations began early in the evolution of the nodulated plants. But this does not explain the development of the symbiosis, which is likely to be a continuous process, rather than one which originated during some "favourable" period, and is now to be found only in nodules. In the apparent absence of an integrating theory the following is proposed.

Symbiotic nitrogen fixation in plants is a stepwise evolutionary development, determined by selection pressure upon both the plant, which requires combined nitrogen, and the heterotrophic microbe, which requires an energy source. This culminates in anatomical adaptations by the plant which can thus house the microbe, provide it with energy, and in its turn carry off the nitrogen.

Scientific investigation has been focused upon symbiosis in plants which possess nodules. There is no known reason, however, why symbiotic fixation should be confined within visible structures, and the possibility that other associations exist should not be ignored. Other associations have been reported in the roots of rye grass[9] and in the rhizosphere of peas[10]. (With peas, in the absence of root-nodule bacteria, carbohydrate is excreted from the roots where it can be utilized by nitrogen-fixing *Azotobacter*. This may be a reversion to the primitive association postulated in (1) below.) But there is a considerable gap between such loose associations as these and the complex and highly specialized legume nodule. It seems indisputable that the latter has evolved through less complex stages before reaching its present degree of organization. The major stages are envisaged as: (1) casual association between free-living nitrogen-fixing bacteria and plants, on the surface of the roots; (2) loose symbiosis on the surface of the root; (3) entry into, and symbiotic establishment within, the cortical tissues of the root; (4) specialization of root tissue, resulting finally in the organized nodule.

Stages 1–4 above are based on the assumption that symbiosis arose through association. Another possibility is that the invading organism was primarily a pathogen, which would eliminate stages 1, 2 and part of 3. But invasion of the legume root, as it occurs now[11], does not exhibit pathogenic characteristics. Moreover, the liverwort-algal symbiosis, involving a specialized structure, has probably arisen through association. It is reasonable, therefore, to suppose that endophytic symbiosis has occurred by mutual adaptation of plant and nitrogen-fixing microbe. Whichever was the mode of entry, there must have been a stage(s) in which symbiosis in the existing nodulated plants occurred before the development of the nodule.

Leaf nodulation as in the Rubiaceae may have arisen similarly, by stages, from association on the leaf surfaces. Nitrogen-fixing bacteria have been

reported on the leaves of tropical plants[12] and the prevalence of bacterial leaf glands in New Zealand plants[13] is suggestive.

The associations between *Nostoc* and the bryophyte, and with certain fungi[4,14], do not fit into this general picture, because *Nostoc* does not depend on the other symbionts for its energy source. (These symbionts could provide *Nostoc* with a more favourable mineral supply, and extend the periods during which water is available for its growth.)

I am indebted to many people, particularly Mr. A. W. Humphries, for suggestions and criticisms, and to Prof. E. J. Underwood for his support.

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First Record of the Elver of the African Eel *Anguilla nebulosa labiata* Peters

Four species of eel have been recorded from those freshwaters of the African continent and the island of Madagascar which enter the Indian Ocean. Of these, *Anguilla mossambica* Peters and *A. bicolor bicolor* McClelland are known from both the mainland and from Madagascar; but the records of *A. nebulosa labiata* Peters and those of *A. marmorata* Quoy and Gaimard refer to the continent and Madagascar respectively[1,2]. Three of these species are 'long-finned' eels and one, *A. bicolor bicolor*, is 'short-finned'.

Elvers of three of the four species of eel have been found. For the mainland Barnard[3] records an elver of *A. mossambica* from Natal and another specimen from the Breede River (Cape Province), and elvers belonging to this species have been taken in Madagascar[1]. The elvers of *A. marmorata* and *A. bicolor bicolor* are known only from Madagascar, and there are no records at all of the elvers of *A. nebulosa labiata*.

In 1956 I received from Mr. G. J. Lockley, fisheries officer for Tanganyika Territory, two elvers which had been collected on January 29 and provisionally identified by Dr. P. H. Greenwood, of the East African Fisheries Research Organization, Jinja, Uganda, as *A. nebulosa labiata*; later Mr. Lockley sent me eleven others taken in mid-February. These thirteen elvers were collected in the Mzinga River at Mtoni, near Dar-es-Salaam, Tanganyika. The water supply for this town is pumped out of the Mzinga River which flows into a tidal system, Mzinga Creek, and the elvers were discovered at a point about 200 yards above high-water mark in this creek and just below the intake of the water supply by Mr. G. Rowe, secretary to the Tanganyika Aquarist Society. The elvers, which ranged from 50·0 to 61·5 mm. in length, were preserved in alcohol, and those of the first sample had retained their shape and pigmentation—characteristics marred in the second due to damage in the post.

The characters by which Ege[1] separates adult eels include colour, dentition and certain body proportions, in particular that of the "distance between verticals through anus and origin of dorsal fin in percentage of total length", a character which in conjunction with vertebral counts, pigmentation of the tail, etc., he also uses to identify elvers. This anodorsal distance formula, when applied to the elvers from Dar-es-Salaam, gave values by which I identified two of the fish as *A. nebulosa labiata* and the remaining eleven as *A. bicolor bicolor*. These values, together with some specimens, were then sent to Dr. V. Ege of the Marinbiologisk Laboratorium, Charlottenlund Slot, Denmark, who had kindly offered to examine them. He confirmed my identification of *A. bicolor bicolor*, which is the only species of eel in Africa with a short dorsal fin, but he suggested that I should check the identity of the two elvers assigned to *A. nebulosa labiata* by a count of the vertebræ. This count, which Dr. Ege also made, agreed with that given for *A. nebulosa labiata*.

Therefore, of the thirteen elvers from Dar-es-Salaam, two (one of the two collected in January and one of the February collection) are *A. nebulosa labiata* and are the first elvers of this species (which is confined to Africa) to be found, and eleven belong to *A. bicolor bicolor* and are the first record of elvers of this eel for the mainland of Africa and the second time they have been recorded from African freshwaters.

Records of elvers from African waters are most welcome since not only do they extend knowledge of the distribution of *Anguilla* spp. but also they throw light on the life-history of eels in Africa about which so little is known.

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Thermostable Liquid Culture Medium for the Minute Inoculum of Human Tubercle Bacilli

Bovine serum or its fraction is generally used in liquid culture media, such as Kirchner[1] or Dubos[2] medium, for the minute inoculum of tubercle bacilli. This makes preparation of the media very cumbersome, and there has been a need for a long time for a thermostable liquid medium the whole of which can be subjected to autoclaving sterilization.

We have devised such a medium, using 'Tween 80' aqueous solution of egg-yolk extract, and we have succeeded in cultivating the minute size of human tubercle bacilli. The present communication deals with the method of preparation of the medium and the results obtained with cultures.

The composition of the medium is as follows:

KH_2PO_4	1·0 gm.
$Na_2HPO_4.12H_2O$	2·0 gm.
Sodium glutamate	3·0 gm.
Sodium citrate	0·1 gm.
$MgSO_4.7H_2O$	0·1 gm.
Ferric ammonium citrate	5·0 mgm.
0·2 per cent Malachite green solution	0·5 ml.
Egg-yolk 'Tween 80' solution extract	100 ml.
Distilled water	900 ml.

A 'Tween 80' water extract of egg-yolk was prepared by extracting 10 gm. of egg-yolk in 100 ml. of 6 per cent aqueous solution of 'Tween 80' with 1 gm. of active charcoal, at 120° C. for 20 min. This egg extract was a yellowish transparent solution and very thermostable as regards its growth-promoting property. This was added to the basal medium. The medium was sterilized by autoclaving at 120° C. for 20 min. without adjustment of *p*H.

Culture results with the medium are shown in Table 1, compared with those with Dubos 'Tween' albumin medium. At the fourteenth day of incubation, the 10^{-7} mgm. inoculum of *H37Rv* strain of *Mycobacterium tuberculosis* had grown equally well in the yolk extract medium and in the 'Tween' albumin medium. Similar results were also obtained when several clinical strains isolated from tuberculosis patients were tested.

Table 1. Mean Relative Grade of Growth at Fourteenth Day of Incubation

	Inoculum size (mgm. in 2 ml. medium)				
Culture medium	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
Yolk extract medium	+++	+++	+++	++	+
	+++	+++	++	++	+
Medium without yolk extract	+++	+	−	−	−
	+++	−	−	−	−
'Tween' albumin medium	+++	+++	++	++	+
	+++	+++	++	++	+

The culture grown in this medium showed a rather dispersed growth, and could therefore be employed as the inoculum for various growth and animal experiments without grinding up the culture. On the other hand, the resistance of many clinical strains to various chemotherapeutic agents could be determined in five days, employing this medium (Imamura, unpublished work). This medium is very convenient from the point of view of simplicity of preparation and the dispersibility of cultures grown on it.

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Distribution of Word Frequencies

The purpose of this communication is to explain, in terms of the theory of information, the implications of the Zipf distribution of word frequencies[1]. The distribution is formally identical with the Pareto income and Willis taxonomic distributions, but the present discussion is restricted to word frequencies. The discussion resembles that of Mandelbrot[2] but is simpler. The discussion by Parker-Rhodes and Joyce[3] also resembles Mandelbrot's, but is fallacious.

Let the population frequencies of the distinct words of a language, arranged in decreasing order, be $p_1, p_2, p_3, \ldots$, where $\Sigma_r p_r = 1$. Let $\varphi(x)$ be the density of words at population frequency x, so that $\int_{p_1}^{p_r} \varphi(x)\,dx = r$. The Zipf distribution can be described either by $\varphi(x) \propto x^{-2}$ or by $p_r \propto 1/(r+a)$, where a is independent of r. If we wish, for formal reasons, to allow r to be unbounded, then it is desirable to introduce a convergence factor[4] and to write $p_r = b\exp(-\varepsilon r)/(r+a)$, where $\varepsilon > 0$ is very small and b is chosen so that $\Sigma p_r = 1$.

Let the effort required to extract the rth word from the memory be $f(r)$. The expected amount of information[5] per word is $-\Sigma_r p_r \log p_r$, so that the expected amount of information per unit of effort is $I = -(\Sigma p_r \log p_r)/(\Sigma f(r) p_r)$. We now assume, not Zipf's distribution, but his principle of least effort for the development of languages. Its natural interpretation is that the population frequencies p_r are such as to minimize I, subject to the restraint $\Sigma p_r = 1$. It follows by Lagrange's method of undetermined multipliers that $p_r = \exp(-cf(r))$, where the positive number c is such that the restraint is satisfied. If the Zipf distribution is true, it follows that $f(r)$ is proportional to $\varepsilon r + \log(r+a)$. This, then, is the interpretation of the Zipf distribution. The term εr is not to be taken too seriously.

If, on the other hand, we make the assumption of Parker-Rhodes and Joyce[3] that $f(r)$ is proportional to r, then p_r would be 2^{-r}, which is inconsistent with the Zipf distribution. It is interesting that the distribution of the number of 'strokes' in connected symbols in Pitman's shorthand is close to the distribution defined by $p_r = 2^{-r}$, according to a frequency count given by Herdan[6]. For this shorthand example, $f(r)$ probably is approximately proportional to r.

I. J. Good

25 Scott House,
Princess Elizabeth Way,
Cheltenham.

[1] Zipf, G. K., "The Psychobiology of Language" (Boston, 1935). "Human Behaviour and the Principle of Least Effort" (Cambridge, Mass., 1949).
[2] Mandelbrot, B., in "Communication Theory", 486, edit. by Willis Jackson (London, 1953); "Information Theory: Third London Symposium", 135 (edit. by E. C. Cherry, London, 1956).
[3] Parker-Rhodes, A. F., and Joyce, T., *Nature*, **178**, 1308 (1956).
[4] Corbet, A. S., Fisher, R. A., and Williams, C. B., *J. Anim. Ecol.*, **12**, 42 (1943). Good, I. J., *Biometrika*, **40**, 237 (1953).
[5] Shannon, C. E., *Bell System Tech. J.*, **27**, 379 and 623 (1948). Wiener, N., "Cybernetics", 75 (New York and Paris, 1948). Good, I. J., "Probability and the Weighing of Evidence", 75 (London and New York, 1950); *Proc. Inst. Elect. Eng.*, C, **103**, 200 (1956).
[6] Herdan, G., "Language as Choice and Chance" (Groningen, 1956).

First, we must apologize for having evidently given the impression in our original communication, especially in our assumption (iv), that we were intending to use information theory in treating the problem. Our aim, however, was to attack the problem without recourse to the assumptions of this theory. These necessarily involve regarding language as consisting of messages, and the words as being, for all statistical purposes, packets of information. This model is unrealistic as applied to real language situations, on the basis of which the faculty of speech is learned and which even in the most sophisticated communities dominate its natural evolution. We accordingly sought for some approach which would avoid the need for the concept of 'information' in the technical sense; our condition (iv) should have been put in the form: "Languages will tend to evolve in such a way that the time required to recall

a given number of distinct words is a minimum". Our unusual mathematical method was designed because of the difficulty in giving an exact formulation of this condition.

To make this approach lead to a definite solution, it is sufficient to regard the evolution envisaged as proceeding according to a statistical estimation procedure, leading to the state where the frequency of a word ranking rth in the order of frequencies, is, for each r, an efficient estimate of the theoretical frequency given by the distribution function which we are seeking. This estimation procedure is that of making the mean effort of memory, which we call 'access-time', a minimum. Of the three points in question, namely, estimation procedure, theoretical word-frequency, and estimated word-frequency, the first is given by our assumptions, and the other two are assumed to tend to coincide as evolution proceeds. Our method is to state the condition that the criterion of minimum effort shall be an efficient statistic for estimating each word-frequency, and to find, as a solution of the resulting integral equation, an expression for the frequency distribution function.

There are thus at issue two ways of looking at language and two models of memory. Language can be regarded either as an information system ('Shannon language') or as composed as lexical units the informational properties of which are irrelevant for memory ('lexeme language'); effort of memory can be taken as either proportional to the frequency-rank of the word recalled (our model), or as approximately proportional to a logarithmic function of the rank (Good's model). The four resulting possibilities may be tabulated thus:

Memory model	View of language: Lexical units (lexeme language)	View of language: Informative symbols (Shannon language)
I. J. Good	Mathematically intractable but clearly distinct from other cases	$p_r = \frac{a}{r}$
Parker-Rhodes and Joyce	$p_r = \frac{a}{r}$	$p_r = \exp(-ar)$

Good, considering only Shannon languages, has to accept the possibility that different memory models apply in different cases; he therefore adheres to the second column of the table. We take the view that it is unlikely that more than one memory function is available, and accordingly adhere to the second row of the table, since we find that our memory model gives the Zipf distribution as a possible solution for the case of a lexeme language. We are gratified to learn that Pitman's shorthand, which may well behave as a Shannon language, having regard to its origin and purpose, also agrees with our model.

On discussion with our colleagues, we find that our theory requires a very much more detailed exposition than can be given here, and we hope that in due course such an exposition may appear in an appropriate journal.

Equation (3) of our original communication was wrongly stated; it should have read:

$$\frac{\int_{\nu_w}^{\nu_1} \nu\varphi(\nu) \cdot \int_{\nu}^{\nu_1} \varphi(\nu)\mathrm{d}\nu.\mathrm{d}\nu}{\int_{\nu_w}^{\nu_1} \nu\varphi(\nu)\mathrm{d}\nu} = \frac{c}{T\nu_w \log (T\nu_w)}$$

A. F. Parker-Rhodes
T. Joyce
Cambridge Language Research Unit,
20 Millington Road,
Cambridge.

Dr. A. F. Parker-Rhodes and Mr. T. Joyce[1] state that if $\varphi(\nu)$ is the number of words in a vocabulary which occur $T\nu$ times in a text of T words, then it has been shown by word counts that $\varphi(\nu) = a/\nu^3$. They put forward a theory to account for this distribution.

If one uses the rather more general form $\varphi(\nu) = b/\nu^m$ and assumes that the function can be treated as continuous up to an upper limit ν_0, then the number of words in the vocabulary with a frequency exceeding ν is

$$\frac{b}{m-1}\left(\frac{1}{\nu^{m-1}} - \frac{1}{\nu_0^{m-1}}\right)$$

and together they occupy a fraction of the text

$$\frac{b}{2-m}\left(\nu_0^{2-m} - \nu^{2-m}\right)$$

Clearly, m must be less than 2 and $b = (2-m)/\nu_0^{2-m}$; it must also exceed unity, otherwise the number of words in the vocabulary is limited to $(2-m)/(1-m)\nu_0$. ν_0 is rather greater than the frequency of the most common word.

The number of different words in a text can be estimated by assuming that all words for which $T\nu$ exceeds unity will appear at least once, and that a selection of rarer words will occur once each. The number of the commoner words in the text will then be

$$\frac{2-m}{(m-1)\nu_0}\left\{(T\nu_0)^{m-1} - 1\right\}$$

and the number of rarer words $T/(T\nu_0)^{2-m}$, giving a total of $\{(T\nu_0)^{m-1} - 2 + m\}/(m-1)\nu_0$.

If $m = 2$, there are no common words and all the words in a text of any length are different—an obviously absurd result. At the other end of the scale, if m exceeds unity only infinitesimally, the number of different words is

$$\frac{1 + \log T\nu_0}{\nu_0}$$

The increase of the number of different words used with the logarithm of the length of the text looks reasonable, but a count of two pages of manuscript taken at random gave a maximum frequency of 0·06, indicating that less than 200 words should exist with a frequency exceeding 10^{-6}, a small vocabulary even for Basic English.

It should be possible to find a formula of the type

$$\varphi(\nu) = \frac{ab}{a\nu + b\nu^3}$$

which is in reasonable agreement with word counts and gives possible results when applied to the number of different words in a text.

This type of distribution would not accord with Parker-Rhodes and Joyce's electromorphic process of repeatedly scanning a mental dictionary; but there is still scope for the application of their idea that language develops in such a way that the maximum of meaning can be conveyed with the minimum of trouble.

C. H. Bosanquet
Dingestow,
Fairfield,
Stockton-on-Tees.

[1] *Nature*, **178**, 1308 (1956).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 18

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (at the Engineers' Club, Albert Square, Manchester), at 4.45 p.m.—Sir Ewart Smith—Clayton Memorial Lecture.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "What is Limiting the Application of Servo Mechanisms in the Electrical Industry ?", opened by Mr. C. Ryder.

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. R. F. Tredre: "Schistosomiasis or Bilharziasis".

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. D. E. Weimer: "Recent Developments in Copper Plating".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Allan Cunningham: "Exploration in the Northernmost Andes".

Tuesday, March 19

IMPERIAL COLLEGE (in the Main Chemistry Lecture Theatre, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. J. M. Kay: "The Nuclear Power Programme and Its Impact on Education".

JOINT COMMITTEE ON STRUCTURAL CONCRETE (at the Royal Empire Society, 18 Northumberland Avenue, London, W.C.2), at 6 p.m.—Dott. Ing. Riccardo Morandi: "Modern Conceptions in the Planning of Bridges in Reinforced Concrete and in Prestressed Concrete".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "The Widening Field of Application of Electronic Computers". Chairman: Dr. A. M. Uttley. Speakers: Dr. A. D. Booth, Prof. A. Tustin and Mr. R. L. Michaelson.

Wednesday, March 20

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. L. C. King: "Basic Palæogeography of Gondwanaland during the Late Palæozoic and Mesozoic Eras".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. T. Pearcey and Mr. G. W. Hill: "Theoretical Estimate of the Collection Efficiencies of Small Droplets"; Mr. T. W. R. East: "Inherent Precipitation Mechanism in Cumulus Clouds"; Mr. P. J. Feteris and Mr. B. J. Mason: Radar Observations of Showers Suggesting a Coalescence Mechanism".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. M. J. Farrell: "The Measurement of Productive Efficiency".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. G. Ainsworth Harrison: "The Measurement and Inheritance of Skin Colour in Man".*

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. V. E. Cosslett and Mr. C. W. Oatley: "Recent Developments in X-ray and Electron Microscopy with some Applications to Radio and Electronics".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. E. H. Leach: "Structural Changes in the Eye caused by Various Diets".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the CHELSEA POLYTECHNIC CHEMICAL SOCIETY, at the Chelsea Polytechnic, Manresa Road, London, S.W.3), at 6.30 p.m.—Mr. D. J. Fry: "Organic Chemistry in the Photographic Industry".

Thursday, March 21

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP, and ROAD AND BUILDING MATERIALS GROUP (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 9.30 a.m.—Symposium on "The Corrosion of Metals in Buildings".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Election of Fellows. 4.30 p.m.—Mr. J. E. Bennett, Mr. J. F. Gibson and Mr. D. J. E. Ingram: "Electron Resonance Studies of Hæmoglobin Derivatives, I: Hæm Plane Orientation"; Mr. C. J. Danby, Mr. J. D. Lambert and Mr. C. M. Mitchell: "Separation of Hydrocarbon Isomers by Thermal Diffusion".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. J. Halpern and Mr. F. A. Forward: "Separation of Uranium and Copper during the Acid Pressure Leaching and Sulphidic Uranium Ores"; and Mr. F. A. Forward and Mr. J. Halpern: "Hydrometallurgical Processes at High Temperatures".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Symposium on "Plant-parasitic Nematoda". Invited speakers: Prof. B. G. Peters, Mr. N. G. Hague, Mr. T. D. Williams, Dr. R. S. Pitcher and Dr. J. E. Crosse.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. W. Gallop, Mr. D. D. Vonberg, Mr. R. J. Post, Mr. W. B. Powell, Mr. M. A. J. Sharp, and Mr. P. J. Waterton: "A Cyclotron for Medical Research".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. S. H. Hollingdale: "The Application of Automatic Digital Computers to Aeronautical Problems".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at the Royal Army Medical College, Millbank, London, S.W.1), at 7.30 p.m.—Laboratory Meeting—Demonstrations. Chairman: Prof. R. M. Gordon, O.B.E.

Friday, March 22

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at the Institute of Physics, 47 Belgrave Square, London, S.W.1), at 11 a.m.—All-day Discussion Meeting on "Low Temperature Distillation".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on papers received during the Session 1956–57. Chairman: Mr. B. C. Browne. Speakers: Mr. J. Darbyshire, Sir Harold Jeffreys, F.R.S., Mr. B. R. Leaton, Mr. A. E. M. Nairn and Dr. R. Stoneley, F.R.S.

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Annual General Meeting.

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (joint meeting with the SOCIETY FOR ANALYTICAL CHEMISTRY, in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Dr. H. Irving: "Organic Reagents in Inorganic Analysis—Some Recent Developments".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. G. V. T. Matthews: "Bird Migration".

Saturday, March 23

NUTRITION SOCIETY (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 10.30 a.m.—Symposium on "Man's Need for Water".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN SCIENCE, NUTRITION AND HEALTH EDUCATION—The Principal, Radbrooke College, Shrewsbury (March 23).

LECTURER IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Liverpool (March 23).

ASSISTANTS IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (March 25).

DEMONSTRATOR or LECTURER (honours graduate in chemistry or biochemistry, or medically qualified) IN CHEMICAL PATHOLOGY—The Registrar, The University, Leeds 2 (March 25).

PHYSICAL, ANALYTICAL and ASSISTANT CHEMISTS in the Research Laboratories, Leatherhead, Surrey, to work on problems arising from the generation of electricity in conventional and nuclear power stations—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. No. N./103 (March 25).

TECHNICIAN (preferably with some practical knowledge of physics and chemistry and capable of taking responsibility for the routine work of an experimental laboratory) FOR THE PLANT PHYSIOLOGICAL LABORATORIES in the Department of Botany—The Registrar, University College of North Wales, Bangor, North Wales (March 25).

JUNIOR RESEARCH FELLOW IN ZOOLOGY—The Registrar, The University, Sheffield (March 30).

LECTURERS IN EXPERIMENTAL PHYSICS—The Secretary of University Court, The University, Glasgow (March 30).

PHARMACOLOGIST/TOXICOLOGIST (with a first- or second-class honours degree in a biological science, and at least three years post-graduate research experience, including some in a branch of pharmacology or toxicology, and preferably with a knowledge of statistical methods) at a Ministry of Supply Establishment near Salisbury, Wilts—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.49/7A (March 30).

SCIENTIFIC OFFICER (organic chemist, with a first- or second-class honours degree or equivalent) AT THE COLONIAL PRODUCTS LABORATORY, Colonial Office, London, S.W.7, for laboratory investigation and intelligence work—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.79/7A (March 30).

SENIOR LECTURER IN INORGANIC CHEMISTRY—The Registrar, The University, Sheffield (March 30).

UNIVERSITY STUDENTS AND FELLOWS for experimental or theoretical research in nuclear and elementary particle physics—The Professor of Natural Philosophy, The University, Glasgow, W.2 (March 30).

LIBRARIAN (with good academic qualifications and experience)—The Secretary, Institute of Education, Malet Street, London, W.C.1 (April 1).

PHYSICIST (with a university honours degree in physics or equivalent qualifications, and preferably with research experience to at least Ph.D. standard) AT THE RADIO RESEARCH LABORATORIES, Camden, N.S.W. (C.S.I.R.O.), to work on problems associated with the propagation of natural and man-made electromagnetic waves through the ionosphere—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 544/2 (April 1).

LECTURER or ASSISTANT LECTURER IN PHYSIOLOGY—The Registrar The University, Sheffield (April 6).

LECTURER or ASSISTANT LECTURER (with qualifications in physical or inorganic chemistry, and preferably experience in radiochemistry) IN CHEMISTRY—The Registrar, The University, Hull (April 6).

LECTURER IN PURE MATHEMATICS at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 8).

LECTURER (with special qualifications in chemical physics and independent research experience in some branch of this subject) IN THE DEPARTMENT OF CHEMISTRY—The Registrar (Room 9 O.R.B.), The University, Reading (April 10).

CHAIR OF PHYSICS; and a SENIOR LECTURER or LECTURER IN PHYSICS at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 13).

ASSISTANT LECTURER IN PHYSICAL or INORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (April 15).

LECTURER or ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Hull (April 15).

Senior Lecturer or Lecturer in Veterinary Anatomy at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 20).

Chair of Anthropology in the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 20 Woburn Square, London, W.C.1 (April 30).

Lecturer in Applied Mathematics or Pure Mathematics; and a Lecturer in Physics—Joint Clerk to the University Court, Queen's College, Dundee (April 30).

Lecturer or Assistant Lecturer in Physics at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 30).

Senior Lecturer in Biochemistry at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

Turner and Newall Research Fellows in Engineering, Inorganic Chemistry, Physics and allied subjects—The Registrar, The University, Manchester (April 30).

English Electric Research Fellow in Aeronautics—The Warden, College of Aeronautics, Cranfield, Bletchley, Bucks (May 1).

Assistant (Grade "B") to teach Physics—The Principal, Technical College, Queen Street South, Huddersfield.

Assistant Professor in the Department of Physiology—The Dean, Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada.

Bacteriologists (2), Senior Scientific Officer or Scientific Officer grade, to assist in work on the nutritional significance of micro-organisms of the digestive tract—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

Experimental Officer or Assistant Experimental Officer (graduate in chemistry or bacteriology), to work on formed constituents of milk leading to spoilage as a rejection test for raw milk—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 57/6.

Graduate (metallurgy, chemistry or physics) in the Information Department, for work dealing with every aspect of the recording and transmission of information on the extraction, manufacture and uses of non-ferrous metals and their alloys—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

Lecturer or Assistant Professor (with graduate training, preferably at the Ph.D. level) of Geophysics—Robert J. Uffen, Department of Physics or Geology, University of Western Ontario, London, Ontario, Canada.

Physicist (with a first- or second-class honours degree, and preferably research experience), for fundamental research on the infra-red spectroscopy of proteins and related substances—The Wool Industries Research Association, Torridon, Headingley, Leeds.

Research Assistant (with an honours degree and some experience of stress analysis and the properties of materials), for research into the process of expanding tubes in high pressure boilers—Prof. Hugh Ford, City and Guilds College, London, S.W.7.

Research Biochemist to work on the fractionation of serum—The Secretary (R), The Hospital for Sick Children, Great Ormond Street, London, W.C.1.

Research Officer (Forest Entomologist) (with a good honours degree in a biological science with special reference to entomology, and at least two years postgraduate experience, and preferably experience in forest entomology) with the East African Agriculture and Forestry Research Organization, Kenya, to collaborate with and advise the forest departments of Kenya, Uganda and Tanganyika in organizing research work and control measures against insect pests of forests and forest products—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/151/01.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Proceedings of the Royal Irish Academy. Vol. 58, Section A, No. 2: Flux of Energy for Elastic Waves in Anisotropic Media. By J. L. Synge. Pp. 13–22. 1*s.* 6*d.* Vol. 58, Section B, No. 3: The Geology of the Northern End of the Leinster Granite. Part 2. Structural Features of the Country Rocks. By J. C. Brindley. Pp. 23–70. 6*s.* 6*d.* Vol. 58, Section B, No. 4: The Precipitation of Serum Proteins by Branched-Chain Paraffinic Compounds. Part 2—The Precipitation of Serum Albumin by Certain Branched-Chain Derivatives of Succinic Acid. By W. McD. Armstrong. Pp. 71–88. 2*s.* (Dublin: Hodges, Figgis and Co., Ltd., 1956.) [111

The World Land Use Survey. Occasional Papers. No. 1: Land Use Studies in the Transvaal Lowveld. By Dr. Monica M. Cole. Pp. 41+37 figures. (Bude, Cornwall: Geographical Publications, Ltd., 1956.) 5*s.* [111

Seventh Report of the National Parks Commission for the year ending 30th September, 1956. Pp. iv+66+8 plates. (London: H.M. Stationery Office, 1956.) 4*s.* 6*d.* net. [151

Report of the Nature Conservancy for the year ended 30th September 1956. Pp. v+82+12 plates. (London: H.M. Stationery Office, 1956.) 4*s.* 6*d.* net. [151

Colonial Office. Annual Report on the East Africa High Commission, 1955. (Colonial No. 326.) Pp. v+81+4 plates. (London: H.M. Stationery Office, 1956.) 5*s.* 6*d.* net. [151

Department of Scientific and Industrial Research: Mechanical Engineering Research Laboratory. Heat Division Paper No. 11: Conversion Factors for Specific Energy, Energy and Pressure. By E. J. Le Fevre. Pp. ii+6. (East Kilbride, Glasgow: Mechanical Engineering Research Laboratory, 1956.) [151

The United Steel Companies Limited. Report and Accounts for the year ended 30th September, 1956. Pp. 24. (Sheffield: The United Steel Companies Limited, 1957.) [151

Institute of Personnel Management. Integration of Social with Technological Change. By The Rt. Hon. the Earl of Halsbury. (Occasional Paper No. 11.) Pp. 11. 2*s.* 6*d.* Industrial Training: an Introduction. By A. Tegla Davies. Pp. 40. 4*s.* 6*d.* (London: Institute of Personnel Management, 1956 and 1957.) [151

University of Cambridge. School of Agriculture Memoirs, No. 28: A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1955—Sept. 30th, 1956. Review Series No. 11: Agricultural Teaching at Cambridge, 1894–1955. By Sir Frank L. Engledow, F.R.S. Pp. 32. (Cambridge: The University, School of Agriculture, 1957.) 3*s.* [291

Association of Universities of the British Commonwealth. Report of the Executive Council together with the Accounts of the Association for the year 1st August, 1955, to 31st July, 1956. Pp. 25. (London: Association of Universities of the British Commonwealth, 1956.) [291

Department of Scientific and Industrial Research. Notes on D.S.I.R. Grants for Graduate Students and Research Workers. Revised January, 1957. Pp. 20. (London: H.M. Stationery Office, 1957.) 1*s.* 3*d.* net. [291

Other Countries

South African Journal of Science. Special Publication No. 1: The Physical Characteristics of the Korana. By C. S. Grobbelaar. Pp. 97–144. (Supplement to Vol. 53, No. 4, November 1956.) (Johannesburg: South African Journal of Science, 1956.) [111

Unesco. Reports and Papers on Mass Communication. No. 20 (July 1956): Catalogue of 50 Popular Science Films. Selected and appraised by the International Scientific Film Association. Pp. 34. (Paris: Unesco; London: H.M. Stationery Office, 1956.) 50 francs; 1*s.*; 0.20 dollars. [111

Bulletin of the Astronomical Institute of the Netherlands. Vol. 13, No. 472 (1956 November 26): The Flux Densities of some Radio Sources at 400 Mc/s. By Ch. L. Seeger, G. Westerhout and H. V. van de Hulst. Pp. 89–110. Vol. 13, No. 473 (1956 December 5): Comparison of the Systems of Photographic Magnitude in Kapteyn's Northern Selected Areas. By L. Plaut. Pp. 111–132. (Sterrewacht, Leiden: Astronomical Institute of the Netherlands, 1956.) [111

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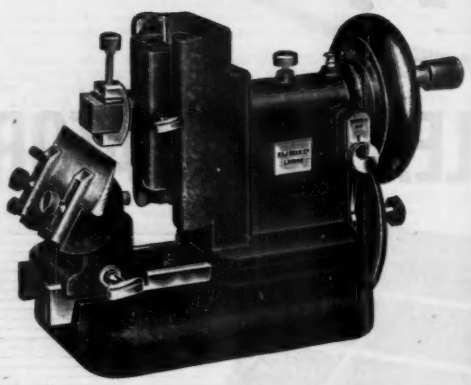

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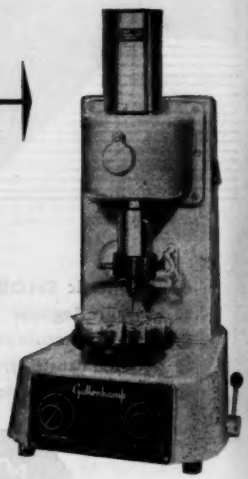

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